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The Artistic Character of Concrete.

In The Engineering Record of Jan. 12 a paper was published on "The Artistic Treatment of Concrete," by Mr. A. O. Elzner, which he recently submitted to the National Association of Cement Users. It draws attention to a most important subject at the present time. The application of Portland cement concrete to a wide range of structures, from the smallest country buildings to long-span bridges, sky-scrapers and even cathedrals, is making extraordinary progress. It is a material economically adaptable to practically every form of masonry construction, as well as to a variety of structures, both light and heavy, which it has been heretofore supposed could be built only of iron or steel.

The first use of concrete in engineering work was naturally in what may be called rather crude masses, such as bridge foundations, piers and the like. Its earlier extensions to lighter structural purposes of a less massive character naturally exhibited more or less of the clumsiness or crudeness belonging to foundation forms, where only mass is required for stability. These results have been so unsatisfactory from an artistic point of view that concrete has acquired in some quarters a reputation of unfitness for graceful or truly artistic structural purposes. Indeed, it is not infrequently called by some architects a "petty" material, unworthy of use in dignified architectural work of the highest order.

It would be interesting to learn just what a "petty" material is in such a relation. Hydraulic cement concrete is an artificial stone, possessing, when properly fabricated and put in place, a carrying capacity equal to that of many excellent natural stones as well as a capacity for endurance against the attacks of fire, frost and ravages of time, as high in some respects as that of the best natural building stones known. It possesses qualities which adapt it admirably to the construction of both light members, especially when reinforced, and heavy structures; and its plastic condition before the setting of the cement enables it to take any desired form with the greatest ease and with perfect accuracy. This quality permits the most graceful lines of strength to be attained in the completed structure. In this respect it possesses marked advantages over natural stone from an æsthetic point of view. A concrete structure may, and should be, so designed as to disclose graceful features easily attained, but which require laborious and costly cutting of natural stone, if the desired results can be attained at all in ordinary masonry.

These considerations show that in the design of concrete structures, engineers should keep scrupulously in view not only stability and strength, but also the capacity for appropriate expression of the material they are dealing with. It is much to be apprehended that the offenses committed by engineers, which unfortunately are being constantly repeated, are responsible for the low esteem entertained by many architects and others for the artistic value of concrete. It is a material which must be classed as artificial stone, and its treatment must be suitable to its nature.

Concrete may be used either en masse or in blocks, and excellent results have been reached by both methods, a suitable form of treatment being imperative for each procedure. Nothing can be more unsatisfactory than some of the types of concrete blocks which are used in different parts of the country for houses and other like buildings. These blocks are made to imitate quarry faced and fine-cut dimension ashlar, or some other types of natural stonework, with the crudest and most hapless failure. Equally unsatisfactory in most cases, from either an æsthetic or structural point of view, is the practice to which resort is occasionally made of marking off by recesses the face of a mass of concrete into make-believe blocks. Any such debauching of character of an excellent building material by these procedures, as usually done, is most unfortunate.

Some admirable concrete block work is now being done in the concrete masonry dams in process of construction in the Croton basin, and at least in one or two reinforced concrete bridges recently completed. There has been no attempt in these cases at a cheap and crude imitation of natural stone, but there has been a straightforward, honest acceptance of the material used. The finest and smoothest surface can be obtained only with a metal-lined form or mold, but a thoroughly satisfactory surface can be secured with a smooth timber mold with no more care than is entirely feasible under the usual circumstances of good work. In the latter case there may be occasionally a little appearance of the grain of the wood under close examination, and some porosity of the surface, but, after all, probably with no more surface imperfections on the whole than first-class natural stones frequently exhibit. The general effect of such concrete block work is in a high degree dignified, and in every way admirable. The results already attained in actual work justify the application of these observations, even to concrete railings and parapet walls.

The employment of concrete en masse is no less satisfactory when intelligently and sensibly done, as is conclusively demonstrated by a great number of completed structures, than in the case of concrete blocks. It is necessary, even imperative, to give the material treatment appropriate to its nature. Flat surface of large area, when properly designed, yield satisfactory effects, and it is easily practicable to give them adequate relief by simple designs well within reach of forms readily constructed. It is possible even to cast excellent moldings in place, where they are suitable. While American experience has not yet been extended far into this region of ornamental concrete construction, enough has already been done to demonstrate its complete practicability and excellence. It is not necessary to make the finished surface of concrete en masse smooth, as various means have already been devised to reach a number of agreeable surface textures entirely consistent with the material.

It seems now altogether probable that the best artistic effects of concrete construction will be reached through structural expression, by means of graceful proportions of members representing lines of strength or stability, although surface effects and ornate details of the highest excellence are quite within the limits of easy adaptability of concrete. It only requires a reasonable amount of common sense and intelligence on the part of the designer, exercised in accordance with elementary æsthetic principles.

Forms of Contracts.

Although much has been said of late in these pages concerning the relations between contractors and their customers, the subject is such a large one that there are unnoticed features of it which will bear thinking over very carefully. One feature of the older practice there is which should not be let slip, and that is the direct relation between the parties which, supposing them both to be fair-minded, led to very satisfactory results. In the recent and, in many cases, highly commendable efforts to escape from the lump-sum contract, with its speculative features, there has come about a condition which is probably responsible for something of the large increase of cost in very many operations. This condition is practically the entrance of the functions of the middleman in one way or another into the formerly simple relations between the man who wanted a block built and the people to whom he made payment. Under the practice of a decade ago, the owner went to the architect and had prepared the plans and the specifications, together with estimates which most generally were somewhat awry. Then bids were called for and when the contract was awarded the successful contractor went ahead; in most cases he gave satisfaction and did a workmanlike job. He occasionally took some chances, but the customer knew from the start the approximate price, and if he thrust in extra costs had only himself to thank. The present tendency to remove the speculative feature, which has ruined many an honest contractor, is in principle a sound one, but its danger lies in substituting a loose and indirect relation for a close one.

In brief, the risk of the modern forms of contract is that the contractor may cease to be a contractor and become a middleman, who merely peddles out patronage where it will do him the most good with the least risk of detection. Contracts which do not fix a limit of cost are practically incentives to graft, not necessarily on the part of the contractor, but all through his organization and among those who sell supplies to him. It is for this reason that the premium plan to which allusion was made last week is a useful one. This journal has a warm feeling for the straight, old-fashioned contractor who did not pretend to be an architect or engineer, but knew how to carry out plans, how to get the best value for his money in material, and the best work out of his men, and who relied for his profit on his own shrewdness and capacity in buying and managing, and not on screwing down his sub-contractors and getting rake-offs on the quiet from the entries on his cost book. It may be that the wheels within wheels which exist in modern business make rake-offs hard to avoid, but they certainly are not discouraged by a long chain of shifty intermediaries between the man who manufactures and the man who pays the bills. In whatever form contracts for work are drawn in the future, engineers should bespeak for them a directness as between buyer and seller that is now too often eluded. The man who builds has a right to expect a square deal. Under older practice he got it unless he fell into the hands of a sharper. Now he gets it if he falls into the hands of an honest man, who can be sure of the honesty of a long chain of other men clear down to the last purchasing agent of the last sub-contractor. It seems to The Engineering Record that there is much to be said for the contract that delivers a specified thing for a given sum, and the main thing is, as a matter of sheer honesty, to specify the work so that contingencies which are not within its proper course shall be dealt with fairly.

Maintenance Charges and Dividends.

There is no more important question before the industrial world at the present time than the need of determining more clearly the relation between the maintenance of equipment and the earning of dividends. In its most far-reaching sense, the definition of the limits of maintenance expense with respect to legitimate profits is a problem of engineering requiring expert economic knowledge in its specific solutions. How can the industrial manager properly balance the claims of the stockholders for a just and reasonable return upon their investment, and the demands of his equipment for rejuvenation, aggravated as they are by a density and volume of traffic which many observers believe have reached the saturation point?

No one is foolish enough to believe that a modern industrial plant, whether it be a railroad system or a carpenter shop, can continue to perform its work year after year without the expenditure of millions or thousands in actual cash in the maintenance of equipment. And yet critics are not wanting at the present time to assert the contrary, with particular reference to the troubles of our great railroad systems in endeavoring to handle the traffic which overflows their lines and impedes the regular and certain movement of their rolling stock. Doubtless it is true that in many cases the equipment is unequal to the task assigned it, and largely because the necessary repairs to keep it in first-class order have not been made; but it is quite another matter to assume that there is a universal tendency to cut down the cost of maintenance in the mistaken belief that it can be done with impunity and for the simple sake of swelling the dividend account.

Whatever may be the surface manifestations of a short-sighted policy with respect to maintenance in any industry which is overcrowded with rush orders, and whatever may be the temporary reason for parsimonious appropriations, the root of the whole matter lies in the executive officers' lack of exact knowledge as to the precise needs of the maintenance account when forecast in the light of the probable business of a month, six months, or a year ahead. A great railroad company, for example, may enlist the combined talents of all its department heads in the effort to secure an accurate estimate of the next half year's traffic. It may order thousands of additional freight cars and hundreds of locomotives, with the idea in view of being able to meet the traffic demands for many months to come, and yet these cars and locomotives may be delayed in delivery far beyond contract guarantees, or they may be inadequate to handle the unprecedented increase of business when they do come. Under such uncertainties, it is a most difficult matter to predict the maintenance appropriation which will be necessary to keep the old equipment moving. Every possible effort must be made to keep the equipment on the road, and only the most necessary and imperative repairs can be permitted.

Nothing but vitalized statistics interpreted with engineering judgment will show the extent to which maintenance expenses are imperative. Comparisons of repair costs in relation to traffic, of wear and tear with respect to the life of both individual parts and complete equipment, must be constantly made and deductions crystallized. It is a hard knot to untie, for the increasing volume of business in all industrial lines, the augmented power and capacity required in equipment, the higher speeds of operation and intensified rate of production, all tend to make comparisons of present and past practice difficult on anything like a common basis. The correct interpretation of future needs in the perspective of the present requires a sense of proportion which is worth many times the usual salary of the executive possessing it. The trouble is that in far too many cases the data are lacking upon which to base an intelligent estimate. Given the necessary knowledge of depreciation and maintenance with respect to work accomplished, the problem of setting aside a proper sum for repairs and replacements will be definite; dividends will not be hazarded by unknown subtractions for upkeep, but can be figured on a reasonably close basis. The fear of falling below the usual dividend rate may deter managers of industrial properties from making adequate appropriations for maintenance, but with more complete data of operating costs and performance there need be no quarrel between maintenance and dividends with respect to the rights and allowances of each.

The Returns of Engineering.

The old, but always interesting, subject of the compensation for engineering services was discussed recently in the annual address of the president of the Pacific Northwest Society of Engineers, whose remarks appear elsewhere in this issue. Most engineers agree that they are not paid enough, but The Engineering Record has heard the same assertion from lawyers, physicians and clergymen. It is a chronic complaint among teachers, and even a contractor occasionally gives voice to it. Assuming for the moment that it is correct with respect to engineers, it may be pointed out that engineering has progressed in public recognition and in its financial returns, far more rapidly than has the law, medicine or the ministry. When the Nestor of American engineers, Mr. Charles Haynes Haswell, was appointed chief engineer of the first steam vessel in our navy, he had to make a vigorous fight to secure any sort of recognition above that of a seaman, but in his lifetime he has seen members of his profession rise to places of professional importance equal to those held by lawyers and physicians. It should be borne in mind that the professional fees of lawyers and physicians are rarely larger than those of engineers. When lawyers and physicians are engaged in salaried work, their compensation, except in judicial position of high rank, is not appreciably greater than that of salaried engineers with equivalent responsibility in the same part of the country. There are at least two engineers in New York whose regular fee for consulting work is $1,000 a day, which is about the highest charge of eminent surgeons, while the enormous fee paid to the late Capt. Eads for services during the early days of the Manchester canal project remains to the present time one of the most thoroughly satisfactory achievements of American professional men. This journal does not believe that at the present time the leading engineers of national reputation have much reason to complain of the sums they can obtain from strictly consulting work.

The situation of those at the other end of the ladder is not so different from that of young lawyers and physicians. No amount of college education can make a lawyer or a physician. The young man just out of a law school, with the ink fresh on the papers admitting him to the bar, has to become a clerk. In most of the large law offices of New York the clerks are paid nothing for a year or more, and one who gets $60 a month after a year's work has to be pretty bright. The head clerk in most large offices, generally an exceptionally bright young man of at least five years' experience in the office, rarely gets more than $150 a month. The average compensation in Chicago and the West is probably lower than this, and accordingly it hardly seems right to consider that the young engineer, who starts in at $60 and rises in a few years to $1,500 or $1,800, is any worse off than the young lawyer. He is certainly better off than the young physician.

It is unquestionably true that the compensation for engineering services in the Northwest is lower than it should be. Competent critics have stated that this is because a considerable number of railway and land surveyors have gone there in times of great activity in construction and, being stranded when construction shut down, have been compelled to take work at any price in order to live. This is a local condition, however, for in the country as a whole engineers are now fairly well paid. It is important to bear in mind that a man is paid what the work is worth and not for what he is able to do. Any engineer in a place worth $200 a month and paid that sum ought to understand he is adequately compensated; if he wishes more he should seek a position where the responsibilities are worth more. Technical knowledge, of itself, is relatively low in value; ability to carry responsibilities and direct the technical work of others efficiently is of higher value. This is the case in law just as in engineering. It is what makes civil engineering such an attractive field for an ambitious young man. As his experience increases and he learns to know his abilities, the field of engineering is wide enough for him to find his place. Of course he must make his way himself, for there is nothing about a moderate amount of engineering information that will make the public rush to secure the services of its over-modest possessor. The Engineering Record is convinced that not only is the compensation of the engineer steadily rising, but it is to-day on a par with that of the architect and chemist. Whether it will long remain so for minor places will depend in no small degree on the ability of the country to find work for all the young men graduated annually from the technical colleges. The higher places in engineering, both professional and salaried, are certain to continue extremely profitable and honorable, and their number is increasing at a gratifying rate.

State Control of Water Supplies.

The governor of New Jersey, Hon. Edward C. Stokes, discusses with admirable lucidity in his annual message to the legislature a number of engineering subjects now attracting attention in that State. The chief of these is the preservation and utilization of potable water supplies; indeed, the Governor considers it the most important problem now before the people. The situation is a peculiar one. About half the population of New Jersey lives within fifty miles of New York and depends for its water supply on two rivers and their tributaries. One of these, the Passaic, has a dry-weather flow of 85,000,000 gal., which has been reduced to barely 35,000,000 gal. by the draft upon it. The draft on the second river, the Hackensack, already exceeds the minimum natural flow. In both cases storage reservoirs materially improve the natural conditions, but this storage must be greatly augmented or potable water will become scarce in the great metropolitan district. There is, however, one promising feature of the situation. The Passaic River is subject to severe floods, which have caused so much damage that the problem of their prevention is a vital one. It has been investigated independently by a special commission and for the State Geologist by Mr. C. C. Vermeule, and both investigations point to the practicability of preventing the floods by constructing a great reservoir. There is a difference of opinion as to the best site for the main dam of this reservoir, and the choice of site is, as the Governor aptly states, "an engineering problem to be solved by experts and not in a legislative message." Enough is known, however, of the two sites to prove that it will be practicable to store in this reservoir an amount of flood water that will insure a bountiful supply throughout this district for many years.

The engineering features of this undertaking apparently do not present serious problems, but the opposite is true of the administrative features, which relate not only to the conservation of valuable water for possible distribution to many communities, but also to the prevention of floods in several cities. The latter are now facing the expenditure of large sums for sewage disposal works, and the appropriation by them of $7,500,000 to prevent floods by constructing this great reservoir is apparently out of the question. The Governor suggests that bonds secured by a mortgage on the reservoir might be issued for a part of the necessary funds, but in view of the fact that the impounded waters rather than the works for impounding them are the real asset, there might be some difficulty in placing the bonds. There are already many reservoirs in the Passaic catchment basin, and the complication of water rights there is not wholly favorable to any easy adjustment of their respective privileges. For this reason, a second method of managing the undertaking, also suggested by Governor Stokes, seems much better. This is to have the work undertaken by the State. In order to do this it will be necessary to amend the State Constitution, but in view of the great success of the Metropolitan water-works of Massachusetts it would doubtless be practicable to secure permission for a somewhat similar undertaking in New Jersey.

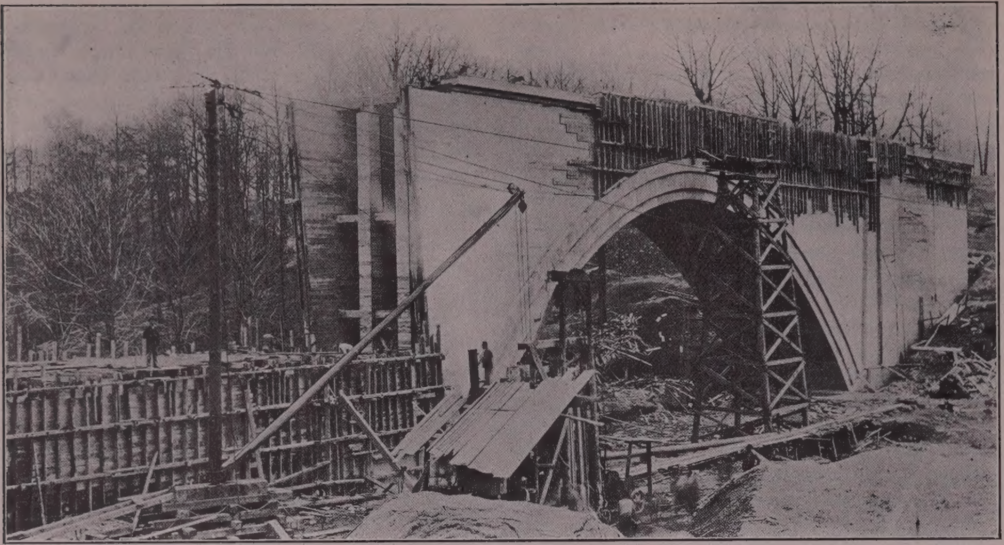
The complicated nature of this problem is due to the fact that powerful corporations already have secured vested water rights in the Passaic and Hackensack valleys, and numerous cities and towns have independent municipal water-works. No conservation of the waters now unappropriated will be practicable which does not also provide for some control of the administration of these public and private works. The population in these districts is growing so rapidly that it is also necessary to exercise some strong control over sewage disposal, lest the supplies become contaminated to such an extent that their satisfactory purification is difficult. Both tasks are best undertaken by a State commission. It accordingly seems that any legislation on the subject should be very carefully considered, for legal and engineering conditions of a complex nature arise if any general laws applicable to the whole State are proposed. In view of the number of commissions which have heretofore studied various features of local water and sewerage conditions, and the absence of any broad plan of State control of water supplies, it would probably clarify present haziness of ideas regarding what can be done if a special board were appointed to report on what has been accomplished in the past and what can probably be safely undertaken in the future in legal and engineering lines. New Jersey already has so many almost powerless permanent commissions that another is not needed, and such a board could probably obtain in three months' time all the information needed by the legislature to organize some new sort of efficient, vigorous and economical control. It would be a great pity to turn the supervision of water supplies over to a body able to do nothing but write annual reports.

Notes and Comments.

AN AUTOMOBILE HIGHWAY along the lines indicated as practicable in this journal recently seems likely to be put under construction at an early date between Weehawken, N. J., at the terminal of one of the New York ferries, and Tuxedo, N. Y. The Motor Car Roadway Co. has been organized for the purpose of building this road and it is understood that the financial arrangements connected with it are practically completed. The road will be 45 miles long and 100 ft. wide, and is intended to be used exclusively by motor cars, which will pay toll for running over it. It is believed that such a road will enable owners of cars to go to and from the city during pleasant weather as rapidly and much more comfortably than by train, while it will afford New York merchants an opportunity to improve their suburban delivery service very materially by putting on automobile wagons. The district served by the proposed road includes the homes of many wealthy people, who use motor cars very largely, and the project is thereby started under the most favorable conditions.

THE IMPORTANCE OF THE MODERN ELEVATOR is well shown by the determination to build another great tower building on Manhattan Island, which will considerably exceed the Singer Building in height, as explained recently in this journal. This latest enterprise will be at the corner of the monumental structure filling an entire city block facing on Mandison Square and owned by the Metropolitan Life Insurance Co. Probably most people regard this great tower rising nearly 650 ft. above the sidewalk as a great architectural achievement, and such it is in one sense. Considered as a business building, however, its very existence depends on the possibility of transporting people rapidly and safely from the sidewalk level to the top story. The old-fashioned elevator service which would make it necessary to spend ten or fifteen minutes for the full trip would render the tower useless for commercial purposes, and not even the great improvements in structural design that have been made possible by the introduction of steel-cage construction would have made such a tower an attractive project in the absence of the high-speed passenger elevator.

THE GATUN DAM AND LOCK SITE was the subject of a note by the engineering committee of the Isthmian Canal Commission recently sent to the Senate Committee on Interoceanic Canals by Chairman Shonts. This memorandum says that investigations by the committee "have thus far led to no disclosure of extraordinary difficulties requiring changes of previous plans." The surveys are being continued to secure "the complete adaptability of the design of locks and other features of the plan to the existing surface and subsurface conditions." The committee, of which Mr. Endicott is chairman, states that there is nothing in the later examinations made affecting the practicability or permanence of the Gatun dam. Two telegrams from Chief Engineer Stevens have also been sent to the Committee. In one of these he states that three lines of holes, 63 in number and extending into rock, have been carried across the Chagres Valley, covering the dam site, and pervious material has been found in but four, and in these only below 200 ft. The second telegram reads as follows: "There have been bored on the site of the locks at Gatun 127 holes, these borings covering at area of 1,200 by 1,200 ft. They show conclusively, in our opinion, that it is possible to build three duplicate locks on this area, having usable dimensions 100 ft. wide by 1,000 ft. long, with foundations for lock walls at all points supported on firm and suitable soft rock. The results of our continued explorations only confirm my previous judgment that we have ample, sufficient and perfectly safe foundations at all lock sites, and were I personally paying for the canal I would have no hesitancy in recommending, in strongest terms, the construction of locks on the sites selected." It is no exaggeration to say that the information in these communications is the most gratifying made public since the unfortunate date when President Roosevelt decided to overrule the advice of the large majority of the engineers appointed to report on the type of canal. It indicates that it is possible, after all, that an 85-ft. canal project is feasible, although few engineers who have been connected with works to impound water will regard with anything but the gravest apprehension the bare statement that the locks must rest on soft rock. It must be borne in mind that the Austin dam which went out some years ago failed because it rested on soft rock, and that the locks at Sault St. Marie, resting on soft rock and subject to a trifling head in comparison with that proposed at Gatun, leak so much that the timber bottom planking is not easily kept in place. With all deference to the marked ability of the Commission's chief engineer as a railroad engineer, it must be acknowledged that before any "soft rock" can be accepted as a suitable material on which to build structures subject to a great hydraulic pressure and vitally important to the safe use of the waterway, an examination of the material by foundation specialists is necessary. This journal sincerely hopes that the site will prove entirely satisfactory, for then the issue raised in next year's presidential campaign regarding the type of canal will be a clean-cut one between two practicable schemes, one for a sea-level canal which can be enlarged as traffic demands, and the other for a waterway perched up in the air and incapable of enlargement or material modification, no matter what faults experience with it demonstrates.



Spandrel Walls and Forms, and Interior Columns and Erection Tower.

THE PINEY CREEK BRIDGE, WASHINGTON, D. C.

A concrete arch bridge 272 ft. long, 25 ft. wide over all and about 50 ft. high from the surface of the water to the roadway has been designed to carry 16th St., Washington, across Piney Creek, and construction has been commenced with a $50,000 appropriation by Congress for that purpose. As this sum is insufficient to build the bridge of the full width considered desirable for the thoroughfare, the plans were made to permit its construction in two symmetrical longitudinal halves, each one of them having its axis parallel to that of the completed bridge and 20 ft. distant from it. The separate halves form complete and independent structures, one of which is shown in the accompanying illustration. After the completion of the second half, at a clear distance of 15 ft. from the first half, the two will be connected by a reinforced concrete platform at the roadway level. The parapet of the first structure will be removed and the widened structure will have a wide roadway and two sidewalks.

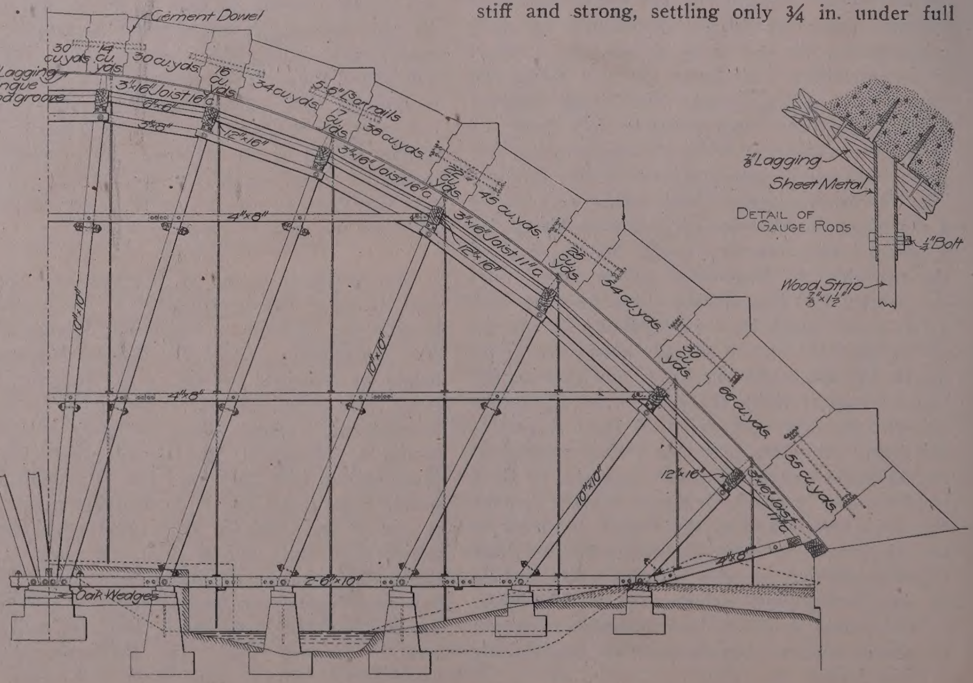
The portion of the bridge now under construction includes a single parabolic arch of 125 ft. span and 39 ft. rise, and two abutments each about 72 ft. long. The arch has a radial thickness of 5 ft. at the crown and 7 ft. at the skewbacks. A parabolic curve was selected both on account of its structural efficiency, the neutral axis and the line of pressure under normal load being almost coincident, and because of its graceful appearance. The abutments have horizontal footings on the dressed surface of the solid rock and are made at the shore end with cells having wall slabs proportioned to receive the thrust of the earth fill. The level roadway 20 ft. wide in the clear, is a reinforced concrete slab 10 in. thick, supported on longitudinal and transverse reinforced beams and girders carried by two lines of reinforced vertical columns over the arch span and by a single longitudinal line of columns at each end of the arch. The spandrel walls are vertical slabs of reinforced concrete, extending from end to end of the bridge with exterior projections to accentuate the lines of the skewback piers and the arch rings. They are made integral with the cornice, on which the balustrade is separately placed.

Vertical expansion joints are made over the skewback piers to provide for temperature changes, and there are vertical construction planes about 70 ft. apart, due to finishing the concrete on opposite sides of them at different times, thus supplying a plane of diminished bond which is normally closed, but provides local weakness to localize any possible openings in the wall. Concrete knee-braces are provided at the intersection of the transverse struts and outside walls, giving additional stiffness and providing for a positive arch action if, in the distant future, the value of the steel reinforcement should be diminished by corrosion. The roadway columns 20 and 30 in. square are reinforced by eight and ten 1-in. vertical rods respectively, and are braced with horizontal longitudinal and transverse struts 12 in. square, reinforced with single 1-in. rods in each corner. Both vertical and horizontal reinforcement rods are tied together with 3/16-in. steel wire at intervals of 9 to 12 in. The columns are seated on horizontal offsets on the upper surface of the arch, to which they are doweled with short steel rods.

The arch and roadway platform are figured for a dead load from the concrete of 150 lb. per cubic foot, which is assumed to be equivalent to 200 lb. per square foot over the full arch span. A live load of 40 tons on two axes 20 ft. apart was assumed and the arch was proportioned for a maximum compression stress of 300 lb. per square inch. Care was taken to avoid paneling the spandrel walls, as it was desired not to diminish the effective proportions of the structure or to imitate in any way the details of granite or marble work. A very satisfactory effect is produced by using yellow bank sand in the concrete for the spring blocks, arch ring, abutment pilasters, abutment belt course, coping and parapet, which are made with a spaded finish, while in the remainder of the spandrel area, the concrete is made with blue stone dust, producing an agreeable contrast. The spring blocks, arch ring, etc., will not be tooled, but the remainder of the spandrel area and abutments will be tooled by using a common pick, in order to bring out the texture of the concrete.

The arch centers are of special radial construction, designed in the office of the chief engineer and consists of five duplicate frames, each of them supported on pairs of wedges driven between the bottom sill and the tops of concrete pedestals built to receive them. The centers are made of long leaf pine timber except the sills, corbels, wedges and other portions subjected to transverse pressure, which are of first-quality white oak. The wedges are tapered 1:10 and sustain a maximum pressure of 300 lb. per square inch. All joints are made with bolts and the maximum deflection was calculated not to exceed ¼ in. The lower ends of the radial posts are continuous through the double sills, and Nos. 3, 4, 5, 6 and 7 are anchored to the pedestals to take the uplift of the wind prior to concreting. These anchors were also designed to take the pressure of high water before the load of the timber was sufficient to hold the sills in place. The anchors consist of 1-in. U-rods passing through the pedestals. The upper ends of these bolts have eyes engaging the horizontal bolts in the feet of the posts and are adjustable with sleeve nuts.

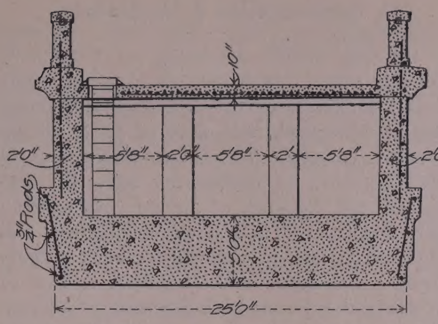
The lagging is made with ⅞-in. tongue and groove boards planed on the upper surface and nailed to the scarf timbers. The centering was framed and assembled on the ground between the abutments and was erected without the use of gin pole or derrick, the two center bents being first erected into position by tackle attached to a tree on higher ground. After they were braced together they served as a stable tower from which ropes were led to erect the remaining bents. The lower ends of the radial posts in the falsework were secured to the double sills with single bolts, which acted as hinges and provided centers around which the timbers were revolved into position in erection and held until braced by the addition of the longitudinal and transverse members. The carpenter work was excellent and the centering proved to be very stiff and strong, settling only ¾ in. under full



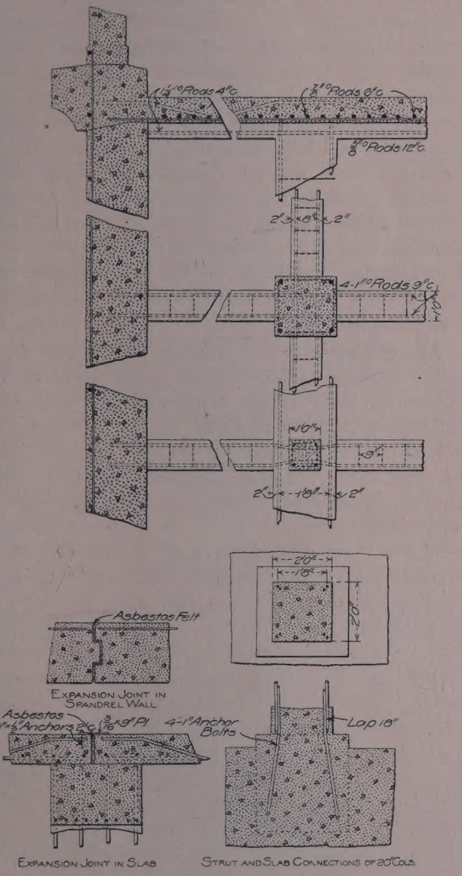
Half-Section of Centering.

load. It was kept in position for 28 days after the completion of the arch and its removal was not followed by any additional settlement in the concrete.

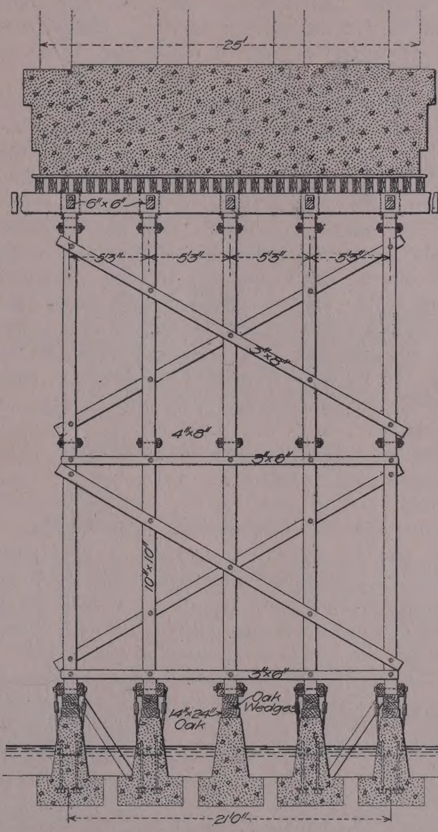
All concrete was made with Giant Portland cement and mixed wet in a Smith concrete mixer located at one end of the bridge; it was delivered in one-yard steel buckets on a low-level service track to derricks which deposited it in the forms. The concrete for all parts of the structure was made of 1 part cement, 2½ parts of sand or stone dust, and 5 parts of broken stone. The stone dust was required to pass through a sieve with 4 meshes to the linear inch, and to be rejected by a 20-mesh sieve. Broken stone 1 in. in diameter was required for the reinforced concrete and 1½ in. for the remainder of the concrete. All concrete was carefully rammed in layers approximately 3 in. thick for the floor slabs and 6 in. thick elsewhere. Wherever new concrete was laid on concrete already set, the surface of the latter was thoroughly washed and covered with 1 : 2 grout, except where it was over



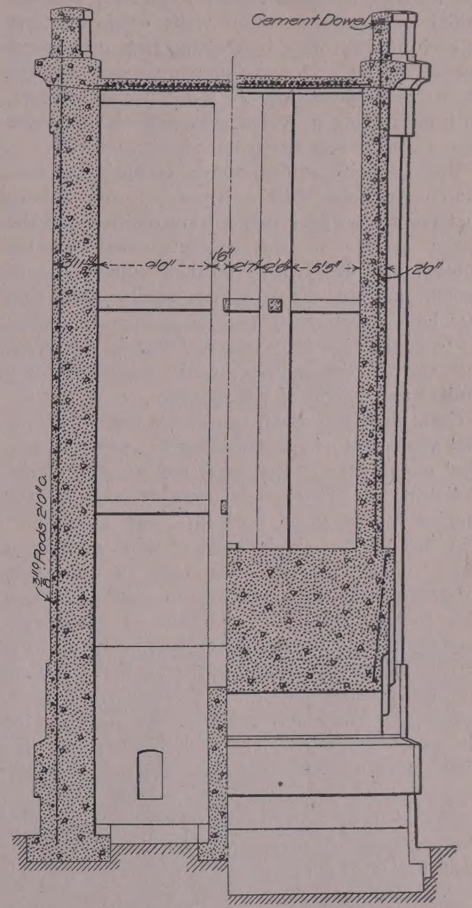
Cross-Section at Crown of Arch.



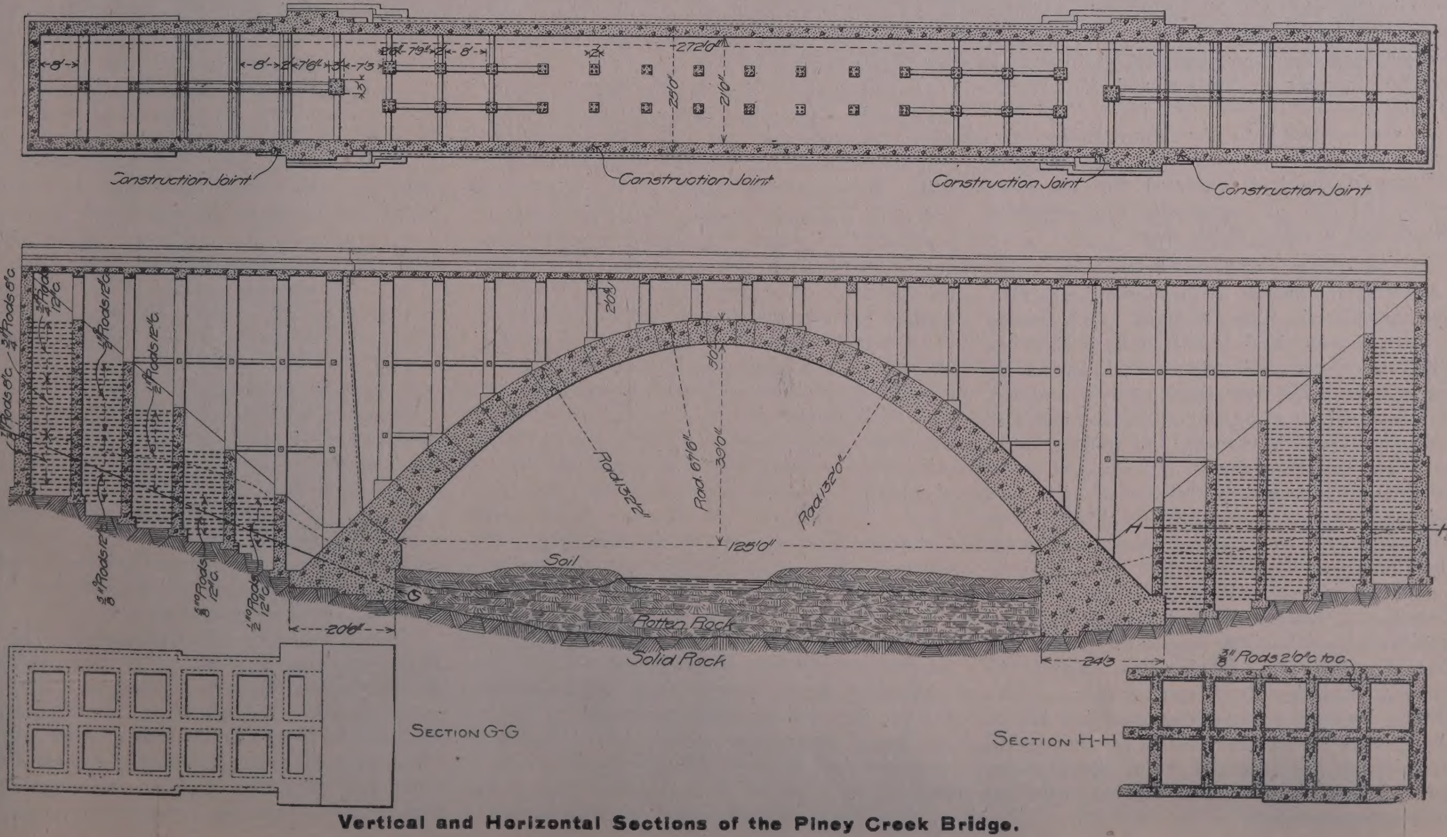
Spandrel Wall, Expansion Joint, Roadway Platform and Vertical Column.



Falsework Bent.



Half-Sections of Abutment and Skewback.



Vertical and Horizontal Sections of the Piney Creek Bridge.

seven days old, in which case cement mortar ¼ in. thick was used.

The arch ring is built in horizontal courses arranged as shown in the elevation of the centering with alternate wide and narrow blocks, connected together by concrete dowels. The narrow blocks project beyond the general line of the extrados to provide seats for the spandrel columns, and were built after the intermediate courses, all of them being constructed in the sequence indicated by the figures on the general elevation. The wide blocks were built between radial transverse partition walls or forms, and in each of them were bedded the ends of I-beams parallel to the arch soffit and projecting through the narrow courses into the adjacent long courses, both ends being provided with riveted transverse base plates serving as anchors in the concrete.

Up to a point 45 deg. above the springing line, the courses were built with upper forms. Above that point the upper forms were omitted and the upper surface of the concrete was troweled smooth and everywhere finished with ½ in. of cement mortar. Each course of the arch ring was built continuously and the work was carried on to completion the same day that it was commenced. In the spandrel walls, concreting was limited to a height of 7 ft. per day.

Great care was taken to observe the deflections and settlement of the centering by means of vertical gauge rods at the upper end of each of the radial posts. These rods were fastened to the lagging by means of steel clips and ¼-in. bolts. The distances of the bottoms of these rods from points on the ground were read as concreting progressed. By these readings the engineers were able to keep track of the effects of the several loads. It is believed that these rods were used on all joints of the falsework for the first time in the construction of the Connecticut Ave. bridge, in Washington, under the direction of the same engineers. The arch blocks were laid simultaneously in symmetrical positions on opposite sides of the center, and no distortion was produced in the centering. The wedges under the centers were driven out by 20-ton jacks, except under the center post, where two 30-ton jacks were used.

The bridge was designed and built under the supervision of the engineering department of the District of Columbia, Col. John Biddle, engineer commissioner; Captain J. J. Morrow, assistant engineer commissioner; Mr. W. J. Douglas, engineer of bridges, and Mr. W. P. Darwin, assistant engineer of bridges. The contract was awarded to the Penn Bridge Co., Beaver Falls, Ohio, T. S. White, chief engineer, for $42,731, and it is expected that the extra orders and cost of engineering and inspection will amount to about $7,000 more.

A THERMAL STORAGE TANK at the South Metropolitan Electric Light & Power Co.'s station at East Greenwich, London, recently blew up, killing two men, injuring several and badly wrecking the boiler house in which it was placed. The drum, which was about 23 ft. long and 5 ft. in diameter, gave way at one end and the larger part was blown through the roof and part of the wall, passing through the brick wall of a shed and finally coming to rest in the wall of another building about 100 yd. from its starting point. The end plate was driven in the opposite direction through the boiler house wall. The fracture, according to "Engineering," occurred along a line running circumferentially around the dished end-plate, in a direction following the radius of the flanging, and had evidently commenced at a point where a leak had been noticed some time before. The leak was being examined at the time of the explosion by an inspector from the National Boiler & General Insurance Co., Ltd., who was one of the men killed.

The Compensation of Engineers.

At the fifth annual convention of the Pacific Northwest Society of Engineers, a considerable part of the address of the president, Mr. James DeRuyter Blackwell, was devoted to a discussion of the compensation paid to engineers. He pointed out that an engineering education was expensive, and the work of the engineer requires a high degree of accuracy, good judgment and fairness. The financial return for such responsibilities is not equal, in his opinion, to that of other professional men having equivalent responsibilities, a fact he attributes to an absence of any general understanding regarding fair compensation for engineering services. His discussion of several aspects of the subject reads as follows:

I think in this connection one or two things should be mentioned that are sometimes practiced by engineers and that undoubtedly hurt the whole profession. One is the seeking of information from manufacturers or agents in reference to engineering details that the engineer should work out for himself. If he cannot work them out, he should not take the job. It seems to me that a client must have little respect for an engineer's knowledge who says to him a certain manufacturer says such and such can be done. If I were the client I would go at once to the manufacturer and save the expense of the engineer.

Another thing that I have never heard was practiced here to any large extent, but is a considerable evil in some eastern sections, is what is known as P. J. work; in plain English, a man who is regularly employed in a salaried position, at no expense for office advertising or materials, taking work out of his regular office hours at rates lower than current for such work. I do not want to be understood as objecting to a man doing all such work that he can where it does not interfere with the discharge of his duty to his employer, but when he begins to cut prices in order to get it he is doing a suicidal thing that will ultimately come home to him. He establishes a price which is used to regulate the charge of his employer, and as the employer is pinched the employee's salary is reduced. If he be a corporation employee, the result is the same, for the corporations make their scales correspond to the prevailing wage and but rarely any higher.

Another practice that in the East has done some harm is employing college students to work during vacation time for extremely low wages. Considered from the student's point of view it may be a profitable business; he is learning, and if he can make expenses while so doing he is ahead of the game. But he finds when he goes out in the world to take care of a family that the engineer's compensation is too small, and he realizes too late that he has helped to make it so. I know of several concerns in the East that made a practice of putting by all work that can be deferred until the vacation season, and from June to September ran 25 to 30 college students, paid from 1.00 to $2.25 per day, the higher figure being often received by men in responsible charge of work. I am told that in the East, the railroads and corporations within reach of the large technical schools can get all the men they want below the rank of division engineer for $75 per month.

I suppose if the question were put to each member of this Society what he considered a fair compensation for an engineer's services, you would hear figures ranging from $3 per day to $25 per day, and from $90 per month to $6,000 and $8,000 per year or probably more. Now we recognize that there are different grades of men and different grades of work, and each man would probably have in mind the compensation for his particular grade and would naturally measure everything according to its standard. Now here is where we get our solar plexus blow when it comes to getting the public to properly appreciate the value of our services, for to the populace in general an engineer is an engineer, regardless of what grade he belongs to or what grade of work he does. As engineers themselves are nowhere near agreed as to their compensation, they cannot expect the public to do anything except endeavor to get every one at the figure of the lowest, no matter what the grade of his work is. A great many engineers who have worked on a salary about all of their time really would not know how to figure out a reasonable rate, based upon the importance of the work, but would be likely to want to work by the day, month or year at a figure based upon what each had been able to induce his employer to pay him in the past, regardless of the importance of the work or the value of his services in connection therewith. Again, there are many times when it is extremely hard to tell what is a reasonable compensation, for it is impossible to tell what the loss might be from the lack of engineering skill.

As an illustration of what it was in one case, quite recently I saw a man construct a plant. He was a very bright, shrewd fellow and was satisfied that he was equal to his job and did not need any engineering services. I told him he probably would lose more time fitting his machinery in without knowing beforehand how it was going to be done than two engineers would cost. He knew better. He set to work, and I watched. First the building had to be raised. I estimated that to cost at least $30; second, his floor had to be cut out for the belt and headers placed to take the ends of the floor joist; this could have been done at first without increased cost. I estimated this cost him $20. Then he got his engine turned wrong end to, and it cost at least $50 to fix it. There were numerous delays owing to changing and resetting machines, that could easily have been prevented by fifteen minutes' work on paper. He told me when he got through that he had spent about $800 more than he had figured the work would cost, and I am satisfied from the time I saw his gangs lose waiting on such changes that at least $300 or $400 of this could easily have been saved. Now he would have felt for the rest of his days that he had been swindled had he paid an engineer $150, and saved as he easily would have, $300 or $400. Assuming the saving to be $350, and that out of this he paid the engineer $150, the cost of the plant being somewhere about $3,000, he would have been ahead $200. Now it probably would have taken an engineer about two days to do what work was necessary on the plant, hence the engineer could have charged $50 or $75 per day without injustice to the employer. As you cannot figure what the loss will be if no engineer is employed, one cannot use this basis. I think the manner on which architects figure their compensation is a fair proposition. It represents about 10 per cent of what would have been saved to the owners had architects been employed in several cases in which they were not and that resulted disastrously by reason of there being no professional advice secured. If such a thing could be done, I would like to see some statistics bearing on the losses to owners not employing engineers that could have been saved had engineers been employed.

I believe the scale of compensation fixed by the surveyors in Chicago on Dec. 26, 1891, is about right for minimum surveyor's charges in Seattle to-day. The scale is as follows: Staking out ordinary house lot, including street grade, $18; staking out ordinary house lot without street grade, $15; giving street grade alone, $10; subdivision into lots in open country, plain rectangular work on cleared and level land, 5-acre tracts, $7 per acre; 10-acre tracts, $5 per acre; 20-acre tracts, $4; 40-acre tracts, $3.75; 80-acre tracts, $3.25; 160-acre tracts, $3; surveying party by the day, party consisting of three men, $25. Surveys are guaranteed correct, and the surveyor to indemnify the owner for all mistakes.

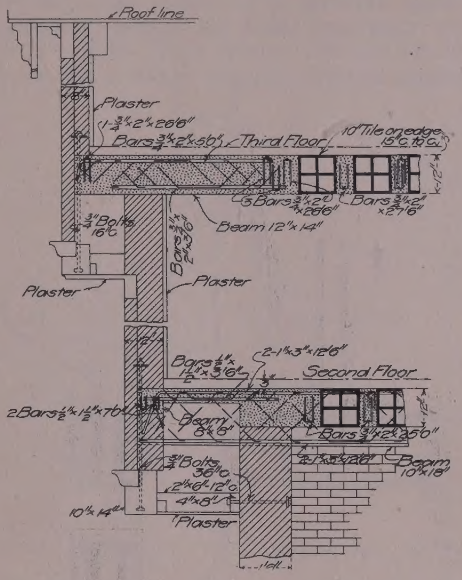
The city of Seattle when called upon to establish corners and give grades on a lot in the downtown district for private individuals makes a minimum charge of $25; but if the work is later checked, it charges $40 or $50.

Engineering services, other than straight surveying, can usually be put under one of the following two heads. Work impossible to apply fixed rates to, such as reports on projects, court work, investigations into projects, lining up projects and so forth, in which the compensation is dependent upon the amount of work and the amount of skill and experience required to do it. This class of work in most cases is such that it should not be done for less than $25 per day for the individual doing the work; it is the class of work usually considered under the head of expert or consulting. The other class is what you might call structural or the work of the constructing engineer, and consist of the design and supervision of buildings, plants and projects, and for this grade of work the following seems reasonable: Full professional services, including active superintendence and management, 10 per cent.; full professional services, including general supervision, 5 per cent.; preliminary study, 1 per cent.; preliminary study, including general drawings and specifications, 2½ per cent.; preliminary study, including detail drawings and specifications, 3½ per cent. Commission computed on entire cost of work, traveling expenses to be paid by client.

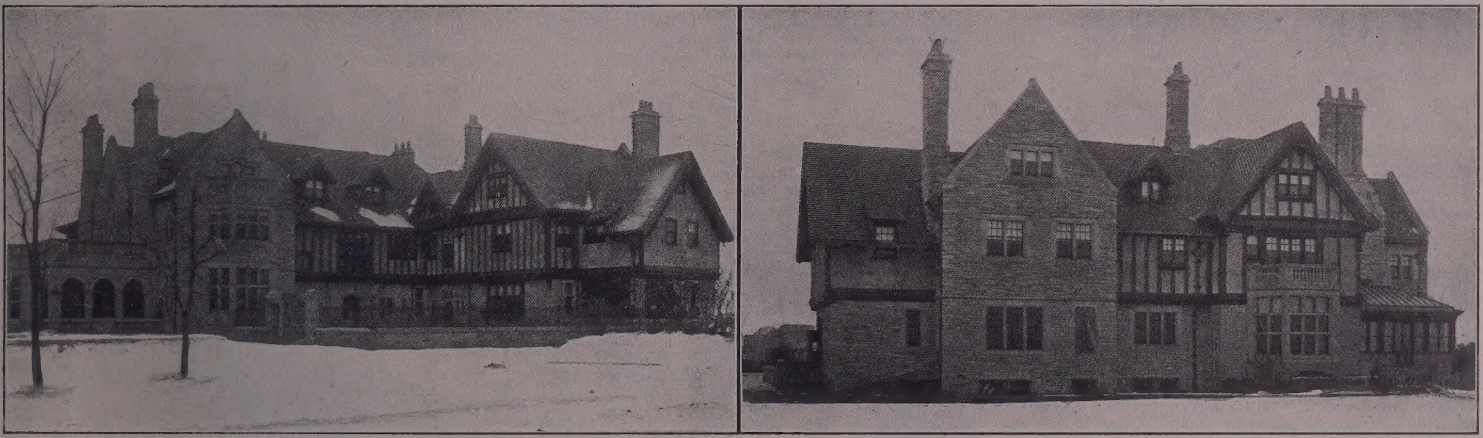
An Automatic Sprinkler System at the works of the Ohio Brass Co., at Mansfield, Ohio, has 3,500 sprinkler heads, arranged on sixteen separate piping systems. A water pressure of about 50 lb. is maintained by both a 50,000-gal. elevated gravity tank and the city water works. In addition there is a fire pump rated at 1,000 gal. per minute, which may draw from the city mains or from a 100,000-gal. reservoir, so that there are three available sources of water supply in case of fire. The gravity tank is a steel standpipe 15 ft. in diameter by 117 ft. high, to which water is supplied directly from the city mains. Check valves are inserted in the connections with the city mains and the tank to prevent a return to either in case of greater pressure in the other while allowing either supply to feed into the sprinkler system freely. With this arrangement, it is found that when about twenty sprinkler heads have opened, the excess pressure of the city system becomes reduced so that the tank begins to feed into the system.

A Large Reinforced Concrete Residence.

The success of reinforced concrete construction in factory and warehouse buildings has come to be so generally recognized and is now so commonly used, that it seems strange that reinforced concrete has not been more generally used in the building of residences. Where this construction has been used it has given satisfaction, and certain features of it have been turned to very good account. An excellent example is found in the residence of Mr. E. Chandler Walker, at Walkerville, Ont. This is one of the first buildings of reinforced concrete to be erected in Canada, and it is worthy of more than passing notice.



Overhanging Wall Construction.



Two Views of the Walker Residence at Walkerville, Ont., Built of Reinforced Concrete.

The main part of this residence is approximately 63 x 127 ft., with a wing at one end 39 x 55 ft. The walls in general are gray limestone, with exposed faces of coursed ashlar. All interior walls are of brick and above the first floor, portions of the exterior walls are brick, some being plastered on the outside, and some face brick being exposed. The roof is red roof tile.

All floors in the house are of reinforced concrete construction put in according to the Kahn system of reinforced concrete and tile construction. In most cases the rooms are not so wide but that the floors can span directly across from brick wall to brick wall. In some cases where a span of 22 or 24 ft. is necessary, this system has been employed satisfactorily. For the floor construction on these long spans 10x12-in. hollow tile are put on edge on 15-in. centers. This makes a floor 12 in. thick. Separating courses are 5x12-in. concrete joists, each reinforced with a ¾x2-in. Kahn trussed bar. The floors of the second and third stories are supported on I-beams. These are of such size, in every case, that it is possible for them to be completely covered by the floor construction. From this a perfectly flat, unbroken ceiling results and the steel work is fireproofed as well. In cases where the floor supports a partition wall, the floor bars are doubled directly under the wall line to give additional strength.

One of the most unusual designs followed is that which allows each floor to project out over the wall of the floor below. The cantilever action resulting is very nicely taken care of in reinforced concrete. The method employed is to extend the main floor over and beyond the wall below, making the projecting portion of solid concrete and reinforcing it with ¾-in. bars on 16-in. centers, running well back into the floor slab. The floor reinforcing bars are also extended into the cantilever and a ¾-in. bar is placed under the supporting wall to keep the slab more rigid. Considering the fact that the floor must support a heavy wall at its extremity in addition to the floor load, this construction is a very economical one.

Special lintels manufactured by the Trussed Concrete Steel Co. were used throughout the residence. They consist of heavy bottom plates to which are riveted flat bands, and these bands are bent up at an angle of 45 deg. The action is the same as that of the Kahn trussed bar. For many of the longer spans, some 14 ft., it was found that this form of lintel was much more satisfactory than any other because of its strength, rigidity, economy and ease of erection.

All the stairs in the house are of reinforced concrete. They are made up of a 6-in. slab on which are superimposed the risers, of solid concrete. The stair slab is reinforced with ½x1½-in. bars. Concrete beams 14 in. deep reinforced with two ¾x2-in. bars are used for framing around the stairways and landings. The landings are made of 4-in. tile with ½-in. reinforcing bars. In addition to the strength and safety of this construction considerable opportunty is given to make a very artistic and effective stairway at a moderate cost. This feature is becoming widely recognized, and concrete is being used more and more for decorative purposes.

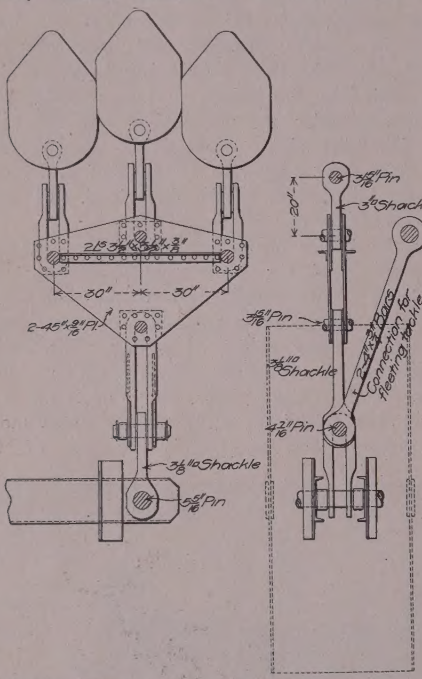
The third floor construction is similar to the first and second, the floors being cantilevered over the second floor walls. The roof is made of roof tile supported on steel trusses.

The Walker residence is a decided departure from the usual construction of dwellings. It has many excellent features, however, which recommend it for similar constructions, chief among which are comparative economy and protection from fire. The interior wood finish in the various rooms does not allow the building to be absolutely fireproof, but the hazard is reduced to almost nothing and the possibility of fire spreading through the house is nil. Rapidity and ease of construction are other characteristics of a structure of this kind.

The structural details for the reinforced concrete portion of this building were furnished by the Trussed Concrete Steel Co., of Detroit. Mr. Albert Kahn, of Detroit, was the architect. The Concrete Steel & Tile Construction Co., of Detroit, installed the reinforced concrete work.

An Unusual Electric Fire.

An unusual electrical fire occurred recently at the Dominion Cotton Mills, at Montreal, Canada. Current is received at the mills from a 2,200-volt, 60-cycle, two-phase transmission line. The current was suddenly cut off at the generating station, allowing the motors in the mill to slow down, and was subsequently thrown on again without notification to the mill electrician. As a result, several coils were instantly burnt out on the synchronous motor of the motor-generator set in operation, and a short circuit was set up of such intensity that, when the main switch was opened on the switchboard to protect the motor, the switch itself was short-circuited and a serious fire started. The short circuits spread to all sections of the board and passed thence to the cables at the rear, burning the insulation on the wires. The switchboard room was soon filled with flames which spread to the wire tower and seriously damaged the entire electrical equipment. As a result of the conditions attending this fire, an insurance expert points out that all rooms containing switchboards or other apparatus of high capacity should be thoroughly fireproofed and isolated from all adjacent rooms and buildings; furthermore, a ready and safe means of controlling the high-tension current from outside of the property should be provided, preferably some form of disconnecting switch by which the circuit may be opened positively in case of trouble.

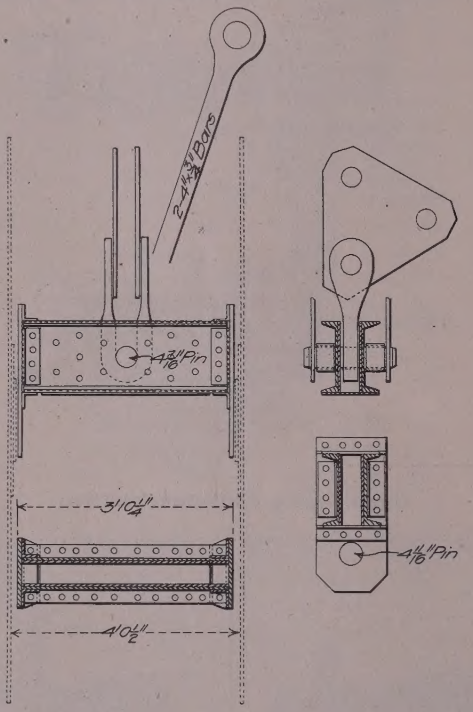


Attachment for Handling Upper End of Center Post Section.

Steel Ties are being tested under running conditions on the Pittsburg division of the Pennsylvania R. R., 3,000 of the Buhrer I-beam type having been laid in main line tracks, and one mile of track laid on longitudinal steel sleepers embedded in rock ballast and held to gauge by cast-iron spacing connections.

Erection of the Main Vertical Posts of the Quebec Bridge.

The general design of the portion of the Quebec cantilever bridge over the St. Lawrence River that has been erected up to the present time was described in this journal on Dec. 1, 1906, when a diagram was published of the principal maximum stresses and materials for the anchor arm trusses. In four subsequent articles important details of design and erection were explained, and the present article will describe the erection of the two main vertical posts, which, with the bracing between them make a bent nearly 415 ft. high by 75 ft. wide over all, on the center line of the main pier. This bent has a total weight of about 3,000,000 lb., and is more than equivalent to a 400-ft. span railroad bridge seated vertically in the same position. It contains some of the heaviest members in the bridge, and its erection was considered one of the most delicate and difficult operations in building the span. The total load of 56,000,000 lb. delivered by it to the pier masonry is carried through a shoe and pedestal at the foot of each vertical post.

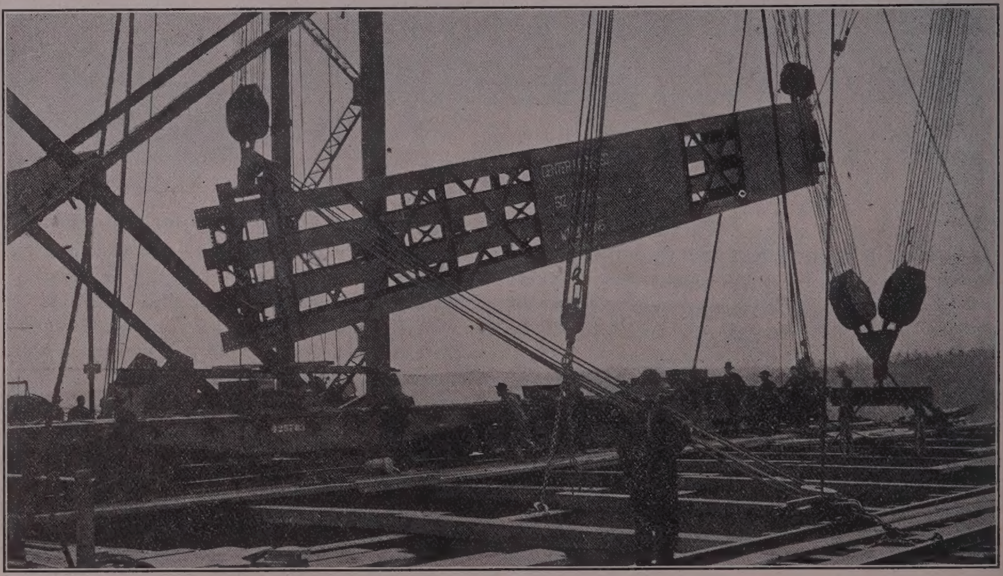


Attachment for Upper End of Main Post.

The pedestals, although neither the heaviest nor longest members in the bridge, have very unusual lateral dimensions, and are so massive that their concentrated weight of 156,000 lb. each made their transportation and erection a unique problem. Each pedestal has an 11x13-ft. base about 8 ft. high, with five longitudinal and five transverse webs. It has a 24-in. pin engaging the shoe on the foot of the vertical post and is provided with heavy connection plates field-riveted to the end lower-chord sections and lateral struts. It was shipped from the bridge shop on a special skeleton steel car, from which it was suspended by a transverse box girder passed through its 24-in. pin-hole.

The pedestal is seated on a bolster 6 ft. high. This has an 18x20-ft. base and is made in upper and lower pieces containing ten and eleven transverse and longitudinal webs respectively. The upper part weighs 95,000 lb., and the bottom part 156,000 lb. In order to facilitate shop work and erection, the connection of the pedestal and truss was made with a 60-ton riveted shoe engaging a short section of the lower chords in the anchor and cantilever arms. All of these pieces, weighing together 565,000 lb., were assembled on the pier, as shown by a photograph published in this journal on Sept. 16, 1905, before the erection of the main vertical posts could be commenced. The tops of the granite pedestals on the piers were very carefully dressed, and on them the bolsters were set on double thicknesses of cotton duck saturated with pure linseed oil and red lead.

The apparatus used for handling the bolsters had two horizontal beams 45 in. apart and 19 ft. long, each made of a pair of 10-in. channels back to back with their webs separated by 3-in. wooden fillers. These beams were inserted between the webs of the bolsters, and through the projecting ends 6-in. pins 18 ft. apart cleared the webs of the lower part of the bolster and received 12x¾-in. U-plates, with transverse pin connections to the triangular plates as shown in the detail illustrations of the device for the connection of two hoisting tackles, described in the issue of Jan. 19. When the tackles were operated, the upper flanges of the beams took bearing against the lower faces of the cap plates in the bolsters. Another pair of holes about 15 ft. apart permitted the pins to be moved closer together for handling the upper portions of the bolsters. The pedestal was lifted by tackles attached to a pair of vertical channels with a 6-in. lower pin engaging its regular pinhole. This operation did not interfere with the assembling of the other members to the pedestal, because they were not connected to it until after

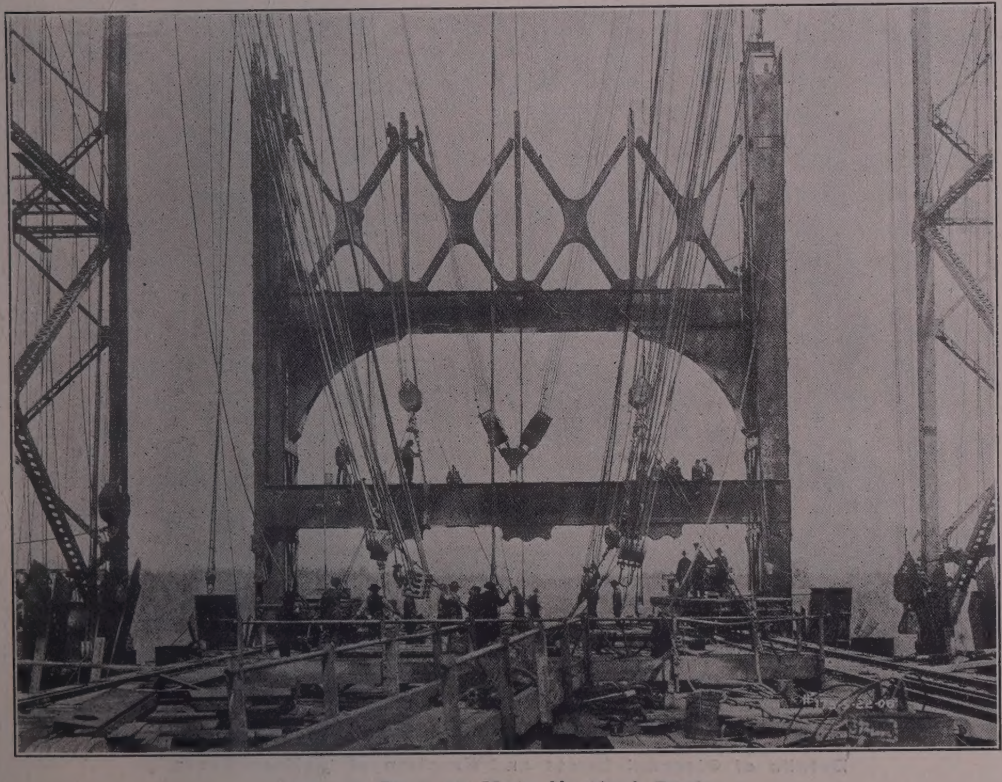


Hoisting a Section of Main Vertical Post.

it was accurately placed on the bolsters and the pin and hoisting tackles removed.

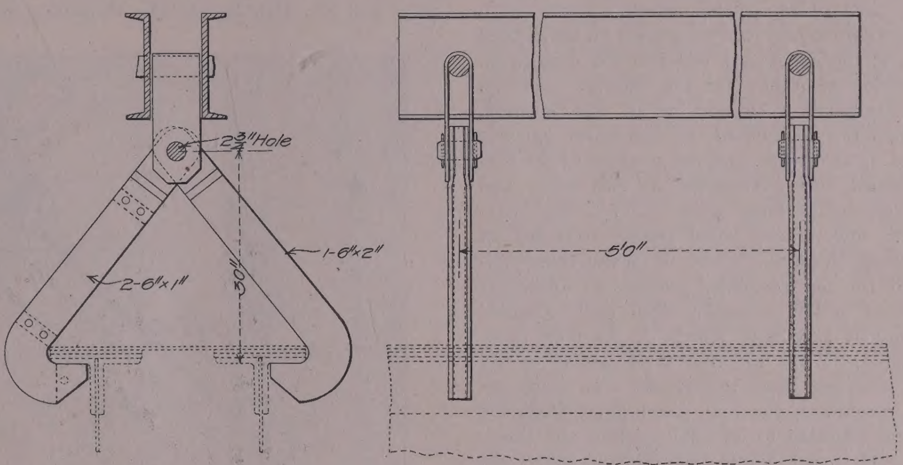
Each of the main vertical posts is 315 ft. high, center to center of pins, and weighs about 350 tons. It has a 5x10-ft. cross-section with four transverse webs, except at the upper end where they are connected to twelve longitudinal webs for pin bearing. This portion of the post, about 10 ft. long, and the 10-ft. portion at the lower end where it is connected to the shoe, each of them weighing about 60 tons, were made separately and shop-riveted through horizontal flanges to the main body of the post. The post itself was made in five nearly equal lengths weighing from about 65 to 92 tons each, and field-spliced with web and cover plates riveted on both sides.

Each section of the post was handled in erection by two 55-ton tackles suspended in the planes of the trusses from jigger beams in the top of the traveler. One tackle was attached with the usual triangular plate connection to a U-plate engaging an 8-in. pin through the projecting ends of a pair of 15-in., 40-lb. channels 11½ ft. long, bolted transversely across the flanges at the lower end of the section. This provided for the hoisting tackle a pivoted connection offset from the web of the post, so that the post could revolve around the pin from a horizontal to a vertical position without fouling the blocks or tackle. The hoisting tackles were attached to the upper ends of the four lower sections of the post by means of a box girder transverse to the axis of the post, with its ends pin-connected to jaw plates temporarily bolted to opposite sides of the post through open holes left for the field-driven splice rivets. The girder consisted of a pair of 15-in. channels with reinforced webs spaced about 5½ in. apart back to back and having their bottom flanges connected by a cover plate. A transverse 4½-in. pin through the centers of the channel webs engaged the U-bars of the device for hoisting the lower ends of the inclined bottom-chord piece, illustrated in the issue of Jan. 10.



Lower Part of Main Vertical Posts.

The upper part of the main post U-10, L-10, is made as already described with a section about 20 ft. long 10 ft. thick and 10 ft. wide, extended beyond the width of the lower portion of the post so as to provide for the connections to the top chords and diagonal members. This upper section or cap was erected in three separate pieces, two weighing 105,000 lb. each and one 35,000 lb. Each of them was provided with three special yokes free to revolve about the horizontal pins connecting them to it. One yoke was attached to the lower end of the member and two were attached at opposite sides of the upper end, hoisting tackles being shackled to each of them clear of the member itself. The member was hoisted in a horizontal position and after it arrived at the required height, was revolved 90 deg. to a vertical position by hoisting on the third tackle, attached to the upper end of the lower side.



Hooks for 36-Ton End Floor-Beam

The first of the three sections was temporarily seated on the transverse bracket attached to the main post for the connection of the upper horizontal strut. The middle and outside pieces of the member were then hoisted in the same manner as the first, and were seated directly in position, the first was moved back and connected with them, and they were finally assembled together and field-riveted in position, completing the post. These members are the highest in the trusses and their details were designed after the construction of the traveler and the dimensions of the hoisting tackles had been fixed, but it fortunately proved that sufficient clearance had been allowed and the operations were successfully performed, although with very little room to spare.

All measurements for the location of the trusses and panel points originate at the east end of the south main pier, where the center of the main vertical post was adopted as a starting point. From it a distance of exactly 550 ft. was measured south in the plane of the truss to locate the end panel point of the cantilever arm on the anchor pier. The center of the main vertical pier in the west truss was found by measuring 67 ft. on top of the pier exactly at right angles to the center line of the east truss, and the end panel point of the anchor arm was obtained by measuring 500 ft. south from this point. The position for it thus located, checked with the position found by measuring directly from the opposite end of the same pier. The measurements were reduced to a normal temperature of 70° Fahr., and were repeated many times to secure great accuracy.. The measurements were made with a standardized 100-ft. steel pipe supported through its entire length on the horizontal falsework platform and pulled to a uniform tension, as indicated by a spring balance.

In determining the erection positions for the bottom chord panel points of the anchor arm, consideration was given to displacement due to camber, to distortion by stress in the members, to variations of temperature, and to possible settlement of the falsework. The displacements due to the first two reasons were accurately calculated, those for temperature were assumed at a certain amount, and provision was made for an allowance for settlement if it should be deemed necessary from careful observation of the falsework when loaded. The algebraic sum of these displacements was determined, and a large scale erection diagram was prepared showing the positions of the bottom-chord panel points when corrected for these displacements and their positions relative to their final location in the completed structure.

The cumulative effect of the displacements was to throw the end lower chord pin 7 17/32 in. south of its final position on the south anchor pier and 1 1/64 in. below its ultimate level. The upper end of the main post was correspondingly deflected about 15 in. to the south, the lower chord panel point L-10 on the center of the main pier remaining absolutely fixed, both during and after erection, and the displacements of the outer points intermediate between it and the extremity of the trusses vary. The end lower chord panel point L-0 is located 81 ft. 1 37/64 in. above the fixed pin in the top of the anchor bars, just above the surface of the pier masonry, and is connected to it by eye-bars free to revolve about the latter in conformity with the displacements of the end chord pin. The pin in the top of the anchor pier was therefore assumed to be fixed and provision was accordingly made for the displacement of the eye-bars and pier shell above it.

It was required that the anchor arm trusses should be erected entirely without initial stress except that which each member received from its own dead load or the weight of adjacent members transmitted through it to the falsework. The trusses were thus at first nearly under the same theoretical stress conditions as if assembled on continuous supports in a horizontal plane. In order to secure this condition, the lower chord panel points were located to correspond with the calculated displacements and different members of the truss were temporarily bent when necessary to permit their connections.

The shell of the anchor tower, illustrated in this journal on Jan. 12, was erected on the anchor pier, and the upper part was inclined south 4 in. to provide clearance for the interior eye-bars, being temporarily blocked up in that position. The required position of the end lower pin was located on the tower, and the erection of the bottom chord was commenced at this point and continued to the main piers. At first the intermediate lower-chord panel points were set at temporary elevations above or below those calculated for the assembled trusses, to allow for the effect of the increasing dead load sustained by them as successive panels of the truss were completed. After the first three panels of the truss, counting from the anchor end, were entirely assembled, the first panel point from the end was adjusted to its final position and thereafter each panel point was adjusted when the erection had been completed two panels in advance, allowance being made at this time for settlement observed in the falsework.

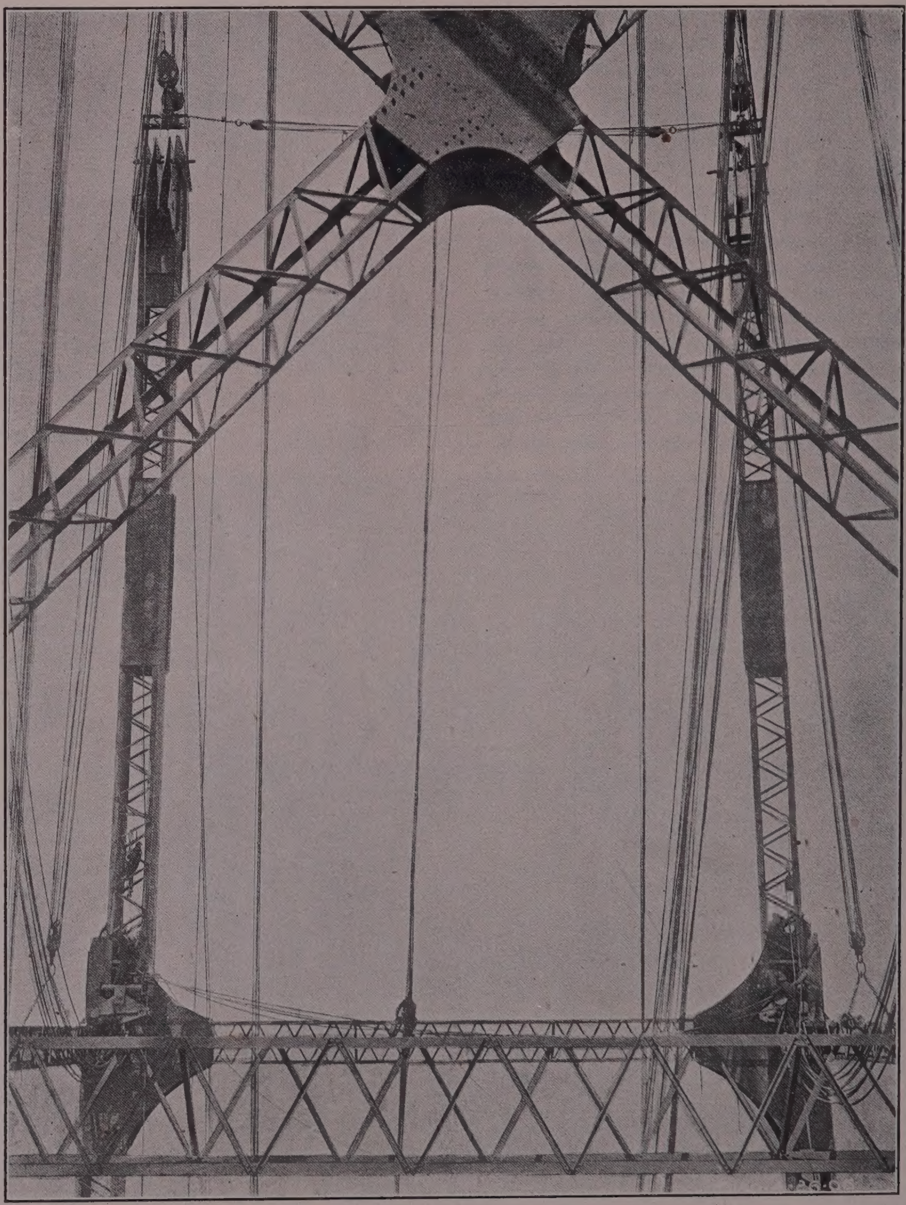
Owing to the parabolic curve of the lower chord, the maximum difference between the erection height and the final height of each chord pin varied from 1 1/64 in. at L-0 at the anchor end to 5⅜ in. at L-5 in the center of the truss. At each bottom chord panel point of the camber diagram, a dotted line sketch was made and dimensioned to show the actual openings between the ends of the chords when they occupied in the initial position, and similar full line sketches to show the openings allowed for camber, which were to be maintained by the erector two panels in the rear of the last complete assembled panel. As the bottom chord is 4½ ft. deep and the positions of its different sections vary from horizontal to an inclination of about 33 to 50, it is evident that the temporary displacements of the panel points cause triangular openings in the butt joints planned to be in contact when the pieces assume their final position. The ends of the chord pieces were placed in contact at the upper or lower flange, as the case might be, according to their position in the curve, and the displacement caused temporary openings of 1/64 to 13/32 in. at the opposite flange.

As the required lengths of the vertical and diagonal posts did not correspond to the dimensions of the temporary distorted triangles formed with them and the diagonal and chord members of the truss, it was necessary, in order to assemble them without stress, to allow their intermediate joints to open in a manner similar to that of the lower-chord joints. This was readily provided for at the splices, where dimension sketches of the diagonals, like those of the lower chord, were given on the erection diagram and indicated the openings of 1/16 to ¼ in. allowed in different cases.

In order to provide for the lateral displacement of the vertical posts at splices, it was also necessary to allow for the displacement of the horizontal longitudinal struts connected to them there, and a diagram was provided showing where the latter should be connected rigidly to the verticals and where a temporary allowance of ½ to 1 5/32 in. should be made at the opposite ends. In some cases notes were made providing for the disconnection of the strut if the allowed clearance proved insufficient for convenient erection.

In making the bottom chord connections, the field-riveting holes in the splices were all filled with service bolts, some of them being full size at points near the vertex of the opening between the ends of the chords and smaller ones being inserted on the opposite side of the opening, to allow for its gradual closure during the erection of the cantilever arm, when the change of stress in the members will gradually bring the anchor arm panel points to their final positions and close the open joints.

Mr. E. A. Hoare is the chief engineer of this bridge and Mr. Theodore Cooper consulting engineer. The contractor for the steelwork is the Phoenix Bridge Co., Mr. John Sterling Deans, chief engineer, Mr. A. B. Milliken, superintendent of erection.



Details of Diagonal Struts and Erection of Inclined Posts.

THE AVERAGE DAILY CONSUMPTION OF WATER in the Boroughs of Manhattan and The Bronx, New York City, is now about 319,000,000 gal., or 133 gal. per capita for a population of nearly 2,400,000. In the report of Mr. I. M. De Verona, Chief of the Department of Water Supply, Gas and Electricity, for 1905, is an estimate of the supply which will be required in these boroughs each year from 1905 to 1915. In the latter year 499,000,000 gal. is the estimated demand, at 153 gal. per capita, for a population of 3,262,000.

Finish for Concrete Surfaces.

A paper read before the National Association of Cement Users by Henry H. Quimby, M. Am. Soc. C. E.

The ordinary concrete structure—whether of building blocks or monolithic masonry, and whether as left by the forms or as commonly finished for exposure to view—is anything but pleasing in appearance, and this fact seems to be the principal reason for the disfavor with which some architects and engineers regard concrete as a material for construction.

The blocks usually have a bubbly, artificial-appearing surface subject to a discoloration that is generally of a sickly or lifeless hue, which offends the eye quite apart from the unpleasant effect of the machine-like regularity of such blocks as are made in imitation of rock-face ashlar. Monolithic concrete is usually finished either by painting with a thin cement wash or by floating, and it is doubtful whether really satisfactory effects have ever been produced by either of these methods on work that was in the forms long enough to get quite hard. The material that ordinarily segregates against the mold forms a skin that seems to have the quality of making very uncertain the attachment to it of any coating, whether of neat cement, paint or of plaster; and if no coating be applied to it and the skin be not removed, the appearance of the work, particularly after a little aging, can be adequately characterized only in language that is too picturesque for a serious paper. There is, therefore, an active demand for a means of putting a better front upon a concrete body without overloading it in cost.

It has been suggested that a stucco finish can probably be made to adhere permanently, and it is reported that a plaster coating mixture of lime, cement and sand has been tried with gratifying results. A very handsome appearance can undoubtedly be thus obtained, but it is generally unlikely that the coating will endure wholly intact, and certain that it will not unless the surface be first carefully prepared for it by some such method as treating with acid or by picking it rough, which altogether would make an expensive finish, and if portions should loosen and come off the condition would be shabbier than anything else that can be conceived.

The mere roughening, however, of the concrete surface to insure the adhesion of a coating of any sort, will itself, if completely and uniformly done, produce a pleasing and ordinarily satisfactory finish—provided, of course, that the concrete has a complete face fully flushed against the forms.

It follows, then, that tooling the surface to the extent of removing the film is a practicable and always available method of finishing it, and the tooling can be done with a bush hammer or an axe, by hand or pneumatic power. The tool should be light, and the blows only heavy enough to "scalp" the work, heavy tools and blows being liable to "stun" the concrete, particularly at and near edges. This scalping partially exposes the material of the aggregate but does not clean it. The complete exposure and cleaning will come with time and exposure to the weather if the work be out doors; or the action of the elements can be anticipated by washing the tooled surface with a half-and-half dilution of hydrochloric acid, which of course must be thoroughly rinsed off.

The cost of such tooling, without subsequent cleaning with acid, has been variously found to be from three to twelve cents per square foot, according to the character and extent of the work and the equipment.

Experiments upon small blocks have shown that a very expeditious method of removing the skin is grinding with a coarse-grained emery or carborundum wheel. The skin is cut about as quickly as the block can be well passed over the wheel, and although no actual comparison has been made and there is no knowledge of a trial of it on large work with a portable wheel, it would seem that with a compressed air or electric motor and a flexible shaft, the emery wheel might be used on any work with about the same facility as a power bush hammer, and the rapidity with which the wheel cuts away the face indicates that such a method of tooling will prove to be no more expensive than bush hammering. The wheel might be small in size and therefore of light weight for convenience in handling, and could be fitted with small guide rollers to limit the depth of cutting and secure reasonable evenness in the dressed surface.

Building blocks have been treated, without the preliminary tooling, by immersion for a sufficient length of time in an acid bath strong enough to dissolve the skin and some of the cement mortar between the particles of the aggregate, exposing and cleaning the particles and even leaving them in relief. This process, which is said to have been patented, includes washing after the acid bath, then immersion in an alkali bath to neutralize any absorbed acid remaining, then final washing with water. It is presumably expensive, is of necessity limited in its application to portable work, and care must be taken to avoid using in the concrete any sand or stone that is liable to injury by the acid.

It thus appears that the removal of the film and exposure to view of the clean aggregate by whatever method obtained is the essential feature of the most certainly durable and generally satisfactory surface finish of concrete. Of course it should be understood that the surface must be fully flushed—must be without cavities or visible voids between the stones. This condition can only be secured, when pressure can not be applied, by using wet concrete thoroughly spaded or forked against practically watertight forms, or by using with stiffer concrete a separate mortar or fine concrete applied against the face form with a trowel just in advance of the body concrete. Stiff concrete will not completely flush against the forms by mere ramming, even if the ramming does work it to a liquid on the top of the layer. Care must be exercised with every portion of the face or voids will occur and appear when the forms are removed, and will necessitate patching. Such repairs cannot be made sightly unless at the time they are made the body is still green—before hard set has taken place. If the surface is accessible while still friable, blemishes can easily be removed without leaving a scar.

This fact suggests the desirability of early removal of the forms, and their removal after the concrete has set sufficiently to maintain itself, but before hard set has taken place, furnishes the opportunity for applying a treatment that is very convenient and inexpensive, yet produces the most pleasing and in all respects most satisfactory finish which has yet become known.

This process consists wholly in scrubbing the fresh surface with a brush and water, thereby removing the film, and with it all impression of the forms, and exposing the clean stone and sand of the concrete. If it be done at the right time—that is, when the material is at the proper degree of set—merely a few rubs of an ordinary house scrubbing brush with a free flow of water to cut and to rinse clean, constitute all the work and apparatus required. A little additional rubbing will bring the larger particles into appreciable relief, which heightens the effect and, in the judgment of most observers, enhances the beauty of the face.

The practicability of removing the forms at the proper time for such treatment depends upon the character of the structure and the conditions under which the work must be done. The system cannot be applied to the soffit of an arch nor to the underside of a reinforced concrete floor, because the centering must be left as support so long that the surface against it is almost stone hard. If, however, the surface material there is the same as at the sides which have been scrubbed, the soffit can be brought to match the sides by tooling and then cleaning with acid and water as before described.

The texture and color of the surface obtained by this process will vary with the character of the aggregate of the concrete, because in a mixture of cement, sand and stone the cement is in small proportionate volume and has but little influence on the color of the ensemble. Some opportunity is thus afforded for the exercise of individual taste in texture and color, and it is very easy to arrange a quiet color scheme in any work that may be suited to it. Warm tones can be obtained by the use of crushed brick or red gravel. A dark colored stone with light sand will produce a surface that resembles gray granite. Fine gravel gives an appearance so like sandstone that even close examination will not enable one to distinguish between them. In the construction of monolithic concrete masonry for bridges for the city of Philadelphia it is the practice to use a fine concrete or granolithic face composed of (1) cement, (2) bank sand, and (3) crushed and cleaned black slaty shale, of the size commonly used for tar roofing—say ¼-in. to ⅜-in. This mixture is placed against the face forms and the body concrete is placed against it and rammed into it immediately. In the three years since this process was adopted and during which it has been applied to twelve bridges, no case of separation of granolithic face has been observed, and not a single hair crack has been found, nor any kind of deterioration or tendency to discoloration noticed—indeed, the weathering seems to make the surface cleaner and more stone-like.

In general the washing is done on the day following that on which the concrete was deposited. Portland cement is used. When a quicker setting cement than usual is met, or through some other influence the surface is found upon removing the forms to be too hard for the scrubbing brush, a wire brush is employed first, then a small block of wood or a brick bat with water and sand, which is found necessary to cut the film.

If the surface has hardened so as to require the grinding action of the sand and block, the aggregate will not be brought out into very decided relief and the face will therefore be comparatively smooth. In cold weather when crystallization proceeds slowly the forms may require to remain two days before the washing can be done safely, and in very cold weather they have been left a whole week and the scrubbing was successful.

Consideration of the cost of the process may involve the question of the design of the forms. When the work is such that not the whole height of it can be placed in one day it may be advisable to construct the form so that the planks can be removed without disturbing the uprights. This will add to the cost but may be compensated for by the saving in planks. In the case of a long or heavy wall where only one course can be laid in a day only one course of planks is required.

If indentations are made at the joints between courses, the joints can easily be concealed. If the indentations are not desired great care must be taken to scrape thoroughly clean the top of each course quite to the face and to use the same consistency of the new granolithic facing as that of the lower course. It is possible thus to make a joint that will not be very noticeable, but the vigilance of the inspector must not be relaxed at any point, and even then the joint will be at least distinguishable. The bead indentations are very convenient and useful in working, and in appearance they relieve what otherwise would be a large blank area.

When the planks are desired to be removable the studs are set some distance from the face, 8 to 12 in., and the planks are braced against them by cleats nailed so as to be easily loosened. The planks are in one width the full depth of a course, either solid or made up of narrow planks battened together. A triangular bead strip is nailed to the face at each edge and the layer of concrete is finished at the middle of the top bead.

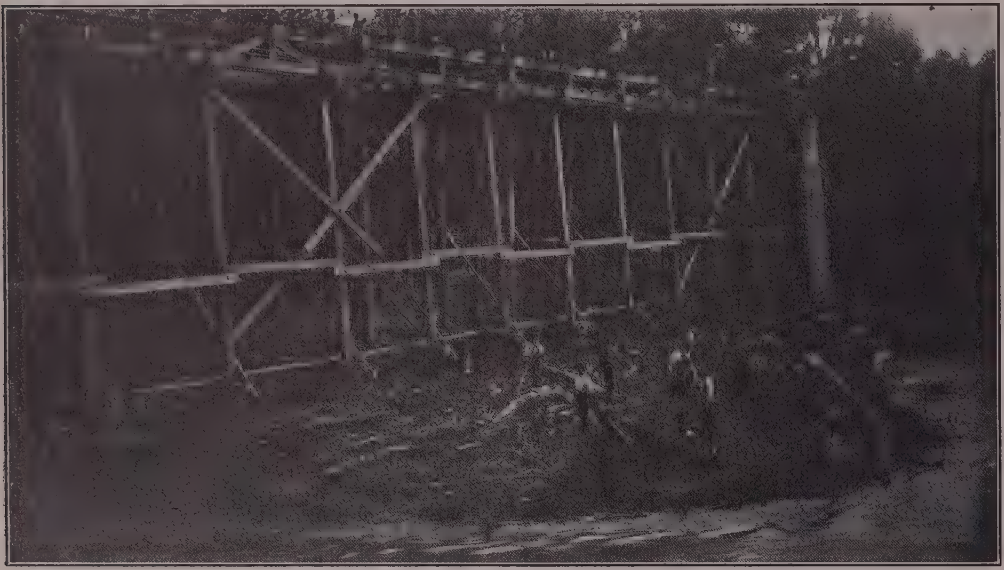
When a plank is taken off it is scraped clean of adhering cement, then oiled, and reset with its bottom bead fitted into the half indentation just left by the top bead.

A couple of carpenters with perhaps a helper will take off and reset a course of plank 100 feet long in four to eight hours. The course may be whatever is desired for either convenience or architectural effect. The yardage of concrete accommodated will vary also with the thickness of the wall and the proportions of face to back. Thus the cost of changing forms will vary from 25 to 75 cents per cubic yard. In building work generally the ordinary forms can be used. Of course care must be taken not to load members too heavily while they are green and naked, but the same care should be exercised with members still in forms, because the forms, while preventing collapse, will not prevent injury to the concrete by undue pressure upon it.

The cost of the scrubbing is trifling if done at the right time. A laborer may wash 100 sq. ft. in an hour, or the same area if it has been permitted to get hard may take two men a whole day to rub into shape.

The early removal of the forms allows the neat repair of any blemishes that may appear.

The question of efflorescence is an important one in the consideration of the appearance of concrete structures. The scrubbed surface is not subject to the hair cracks that in some faces seem to absorb moisture during storms and then exude the white spreading disfigurement. But if there are joints in the work there is danger of the efflorescence, and observation leads to the belief that if within twenty-four hours of the completion of a course the top surface be carefully scraped to remove every particle of the laitance, and then before depositing the next layer of concrete the scraped surface be coated with thin cement mortar, the joint ought to be impervious to moisture from either front or back, and no trouble with efflorescence ensue.



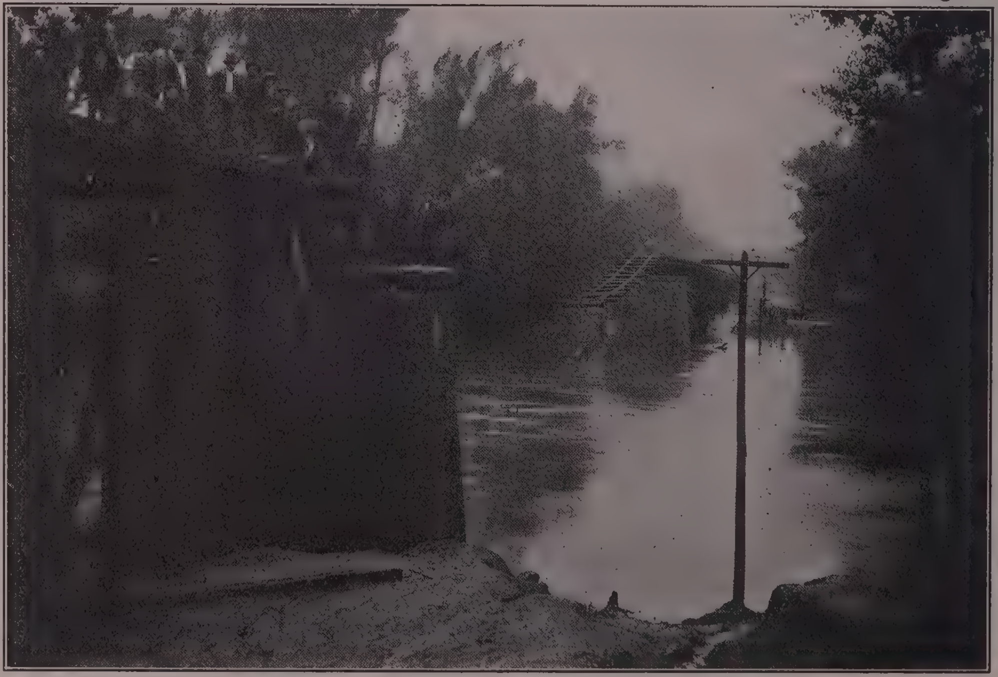
Drift Accumulated Against Falsework.

A Steel Stack, 120 ft. high and 7 ft. in diameter, made in three sections, 45 ft., 40 ft. and 35 ft. long, respectively, from bottom to top, was erected for the Sulphide Corporation, Ltd., at Broken Hill, Australia, by methods described in a paper by Mr. James Hebbard, in a paper before the Australian Institute of Mechanical Engineers. The plates of the stack vary in thickness from 5/16 to 3/16 in. The sections are fastened together at each joint by 44 ⅝-in. bolts passing through the outstanding flange of a 3x3x⅜-in. L-iron, welded joint, ring riveted to each section. Before the erection was begun two small derricks were secured to brackets placed on the inside of the lowest section of the stack near its top. Two large derricks were then set up on the ground and served to put the first section of the stack in place. After it had been secured to the base the two small derricks already mentioned were used to hoist into position two larger derricks which were attached to strong brackets bolted to the outside of the pipe near its top. These were in each case simply a timber mast attached to the bracket by a hinge with its pin parallel to the horizontal bar of the bracket. Guy wires held the masts in place. The smaller derricks were next removed and bolted inside the second section, which was then hoisted with the large derricks. These in turn were again hoisted and served to raise the top section into place. The purpose of the hinges at the brackets was to allow the derricks to be canted so the sections could be hoisted clear of those already erected.

The Wreck of the Washita Bridge Falsework.

The line of the Choctaw, Oklahoma & Gulf R. R. crosses the Washita River, near Fishoming, Ind. Ter., on a 162-ft. pin-connected through-truss single-track span. Piles driven with a hammer operated by mule power were driven to a depth of about 12 ft. in the dry bed of the river and were capped with a falsework of framed timber about 50 ft. high, on which the traveler track had been placed when a sudden flood occurred and the water attained a depth of 35 ft. in a single night. A large force of men was immediately employed to divert the drift and prevent it from accumulating on the up-stream side of the falsework. Part of the gang descended to the water level and disengaged the smaller pieces of logs and rubbish and guided them between the falsework bents. Others operated runner lines from the hoisting engine to haul large logs and trees out of the mass and pass them through the most available openings. They worked desperately for 36 hours and had some hope of saving the structure until the increased amount of drift carried by the flood accumulated faster than it could be removed and, with the strong current, produced a pressure on the falsework that finally caused it to yield.

Sufficient warning was given by the creaking and swaying to enable the men to escape to a place of safety when the entire eleven bents were destroyed, most of the five piles in each being sheared off at the surface of the ground, although some of them were pulled out. The track rails, being bolted together with fish plates at all joints, were pulled off the caps of the falsework and, with the ties which were spiked to them, remained in line, forming a sort of suspension bridge between the main piers, on which the men crossed in couples carrying a horizontal transverse stick between them to enable them to walk the rails together. None of the falsework was recovered, but when the flood subsided it was rebuilt as at first, and the deck span, which weighed about 200 tons and was fabricated by Milliken Bros., was erected without further trouble by the Terry & Tench Construction Co.



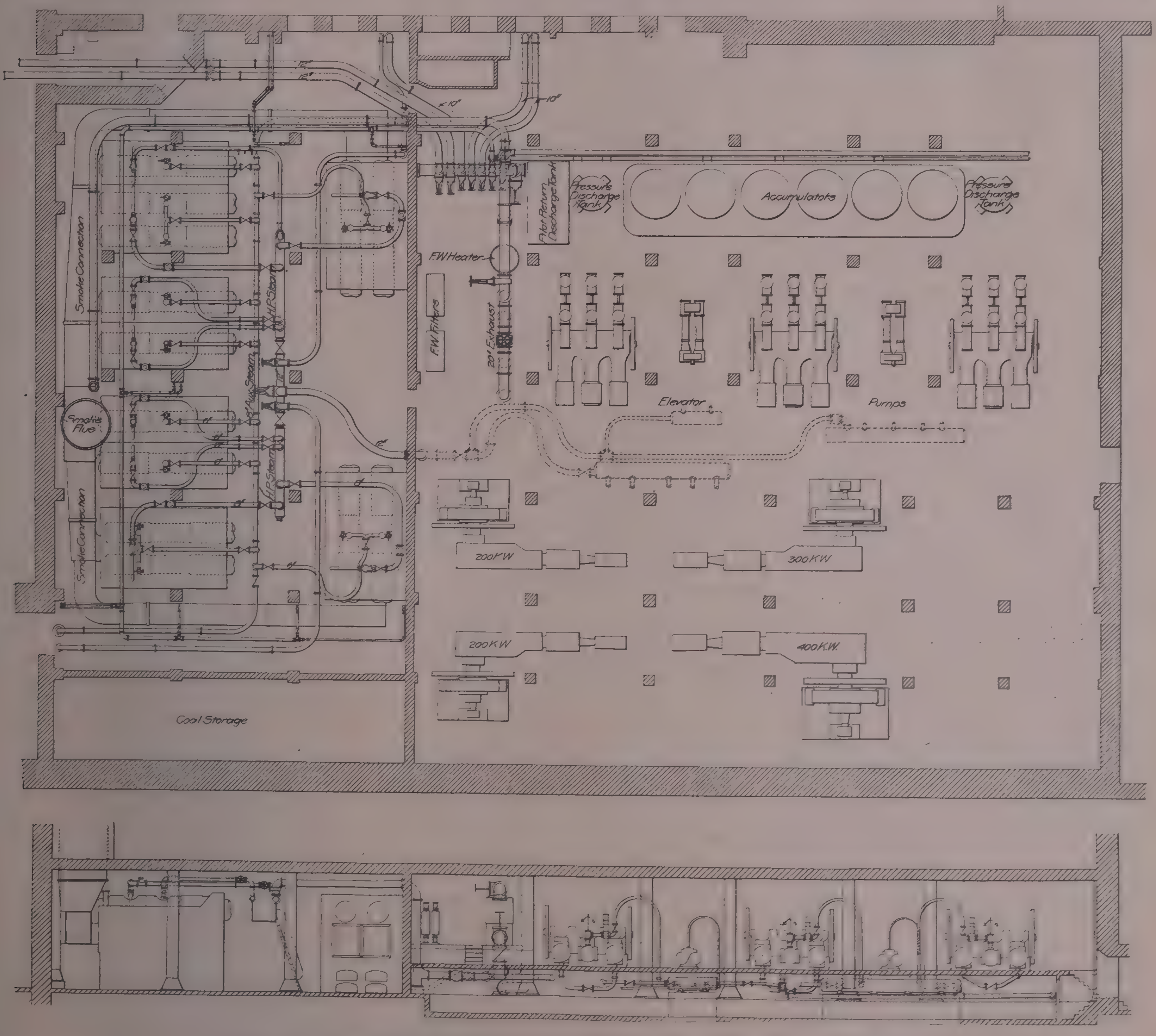
Rails Connecting Piers After Destruction of Falsework.

A Self-Starting Gas Engine.

A self-starting gas engine has recently been devised which employs compressed air for starting, but not by the usual method of temporarily using one cylinder as an air motor. The engine has five cylinders and an arrangement of crank shaft and valve mechanism by which one inlet valve is partly or wholly open at all times. Compressed air is delivered directly to the intake manifold in starting, from which it will enter the open cylinder. The compressed air is admitted through a closed-type carburetor, a check valve in the intake preventing its escape at that point, and the engine begins to turn over until all five cylinders have thus received a charge of a combustible mixture. At this time, the first cylinder has compressed the charge admitted to it, and is then fired in the usual way, starting the engine. In the starting, while each piston is rising on the compression stroke, the exhaust valve of its cylinder is lifted by a cam to relieve the pressure somewhat and prevent compression to the point of preignition. These cams are operated by a single lever interlocked with the compressed air supply, and are thrown out of action when the compressed air is shut off, after the engine is in operation. The compressed air supply is furnished by a pump attached to the valve shaft which is automatically controlled to maintain a pressure of 100 lb. in a storage tank.

The Power Plant of the Metropolitan Life Building, New York.

The building of the Metropolitan Life Insurance Co. at 23rd St. and Madison Ave., New York City, which has recently been enlarged by several extensions and is now being further extended, is one of the largest office buildings in the world. It occupies an entire city block 200 ft. wide by 425 ft. long, facing Madison Square. It is a steel-cage structure 11 stories high, except at the 75x150-ft. corner at 24th St. and Madison Ave., formerly occupied by a church, where an imposing tower will shortly rise to a height of 658 ft. In addition to the main structure, there is a 75x100-ft. annex across 24th St. in the middle of the block; this is a 16-story building erected for the printing departments of the Metropolitan Life Insurance Co. on the lower floors, with rented offices on the upper floors. Further information regarding the building will be found in The Engineering Record of March 3, 1906, and Jan. 12, 1907.



Plan and Cross Section of the Power Plant, Showing High Pressure Piping.

As the mechanical equipment of the original portion of the building was inadequate for either the extended main building or the annex, an entirely new plant has been installed under the central portion of the extension, to provide the heat, light and power for the entire main building and annex. There is a boiler plant of nearly 2,300 h.-p., an electrical equipment of 1,100 kw. capacity, the machinery for 44 high-pressure elevators, and heating, ventilating and other auxiliary apparatus. The power plant is in a 175x230-ft. section of the basement, which has for the greater part a clear headroom of 14 ft., except in the boiler room, which is depressed for a clear headroom of 20 ft. Under the engine room there is a pipe cellar with 7½ ft. headroom through the central portion and 4½ ft. at the sides, for convenience in making connections. The space allotted to the boilers is 60x123 ft., that for the engines is 110x123 ft. and that for the pumps, filters, elevator machinery and other auxiliaries is 95x112 ft.

Boiler Plant.—There are nine Babcock & Wilcox boilers, seven in a row at the west side of the boiler room and the other two in the forward corners, facing the center of the room. Five are of 190 h.-p., two of 300 h.-p. and two of 375 h.-p. Three of the larger units are set single, four of the smaller units in the center of the room are in batteries of two each, and a large and a small unit are in a single battery in a corner of the room. The heating surfaces are 4-in. wrought iron tubes, 18 ft. long, ten to a section. The three sizes of boilers have 9, 14 and 18 sections with heating surfaces of 1,872, 2,912 and 3,744 sq. ft. each, respectively. All have forged steel headers, and steam drums 42 in. in diameter by 20½ ft. long, made of ½-in. steel. All are fitted with Babcock & Wilcox superheaters designed to raise the temperature of steam delivered to 400° Fahr., a superheat of about 50° Fahr. Their construction avoids the use of cast fittings or flanges in the path of the gases, and is such that any one of the superheater tubes is removable without disturbing the others. There is a flooding connection for filling the superheater with water during the process of raising steam or when saturated steam only is wanted.

The boiler settings have 17 in. side walls, 12 in. rear walls, and 16 in. front walls, all lined with fire brick and faced with white-enameled brick. The bridge wall is 24 in. thick and built entirely of fire brick. The tube sections are flexibly suspended in the settings. The boilers are hand fired, the furnace being fitted with McClave shaking grates for burning low-grade anthracite fuel. Above the grates are Roberts flame arches of the reverberatory type. The smoke connections to the chimney consist of black iron ducts of No. 10 gauge, carried at the sides and rear of the room to the base of the stack. The connection to each boiler is fitted with a damper, while the main stack connection has a swinging damper placed in the vertical smoke flue and controlled by a Locke automatic regulator. The steel stack is 8 ft. in diameter inside, and is carried up about 200 ft. to a point above the roof line.

Coal is stored in large bunkers under the 23rd St. sidewalk and extending half the length of the block. The space is about 25 ft. wide by over 200 ft. long and will easily hold 2,500 tons, and 3,000 tons if the piles are trimmed. All coal is dumped directly into the bunkers from the street through sidewalk coal holes, while an I-beam trolley runway is installed for handling it to the boilers. The track is an 8-in. I-beam hung from the ceiling, and extends from the boiler room through a passage between the building columns and the bunkers, with switches into all portions of the bunkers. Several trolleys are provided with chain hoists for lifting and lowering the buckets. Ashes are taken in cans to the sidewalk for collection by the city; they are similarly handled from the boiler room by the same trolley runway to a sidewalk elevator in the bunker space.

The boiler feed system consists of three 7½x5x6-in. duplex steam pumps, a Berryman vertical feed-water heater, a bronze main feed line, and an independent injector on each boiler. The pumps return condensation from the heating returns and drip tanks, with make-up of filtered city water. The feed is heated in the cooling coils of the blow-off tank and the two drip tanks, and then in the feed-water heater; the latter is of the closed type and contains 873 sq. ft. of heating surface formed of seamless brass tubing expanded into steel tube sheets. The water is delivered through Ward filters to a feed line running from the elevated platform in the engine room on which are the pumps and heater, to the rear of the boilers, where it parallels the blow-off main and has 2-in. branches to each of the boilers. Each branch is fitted with a valve at the rear of the boiler near the main and a check and graduating feed valve at the front in the riser leading to the steam drum. The injectors are at the sides of the boiler settings, with steam connections from the saturated steam nozzles and water supplies from a main at the rear of the boilers. There are also 2-in. connections to the feed branches from a boiler washing and testing main at the rear of the boilers.

Water for drinking, lavatory, boiler feed and general purposes is taken from the city mains through two sets of Loomis sand and charcoal filters. Each set has an 8-ft. sand filter and two 6-ft. charcoal filters, and has a capacity of 10,000 gal. per hour. For water closets and general cleaning purposes, for which separate plumbing has been installed, use is made of local ground water. Owing to the excessive ground water found during the construction of the building, a number of sumps were constructed to prevent flooding the basements. This flow of water subsequently proved to be constant and of a fairly good quality. It is filtered roughly in a 10-ft. sand tank which renders the water practically clear. This water has been used for the purpose mentioned since connections were established, and with a material saving in water charges. The water wasted in washing the main filters is now discharged into the sumps and utilized in this auxiliary system, so that the latter is amply supplied.

The boiler blow-off system has a header at the rear of the settings, with 2-in. branches to the mud drums, of which each large boiler has three and each small boiler one. There are also 1½-in. blow-off connections to the superheater coils and the usual connections to the heater, filters and muffler tank. The blow-off main runs in a trench at the rear of the boiler room to a 4x10-ft. cylindrical blow-off tank, fitted with a cooling coil for reducing the temperature of the discharge before entering the sewer. The cooling coil consists of 75 lin. ft. of 3-in. brass piping through which water is passed by the pumps before entering the feed-water heater, by which a considerable amount of waste heat is reclaimed. The tank is automatically drained by a steam pump under the control of a float which maintains the tank constantly half full.

Piping.—There are two steam piping systems, one for superheated and the other for saturated steam. The former has a header main in the boiler room from which connection is made to the units in the engine room through receiver drums in the basement, which permit short individual connections to each of the units. The boiler-room header is a 12-in. main extending through the room over the firing floor. From this a single 12-in. line is extended into the engine-room basement and connects with three distributing drums. The header is of extra heavy piping fitted with Van Stone joints, and has 6 and 8-in. branches to boilers, each branch having a gate and a non-return stop valve. From this header, there are but three delivery connections, one an 8-in. line to an air compressor for the pneumatic tube service of a branch post office in the building, another 8-in. branch to a pressure-reducing valve for live steam supply to the heating system, with a 5-in. extension to the pump room, and the 12-in. main to the engine-room basement.

The receivers are long drums of small diameter, located centrally with respect to the machines they supply. The largest is 30 in. x 22 ft. and has a 10-in. branch from the main steam line; it is under the engines and from it two 5-in. and two 6-in. short lines lead to the four electric units. At the rear of this drum is one 24-in. by 8-ft., having a 6-in. connection from the steam main, a 5-in. connection to one of the high-duty elevator pumps, and a 2½-in. line to a pilot return pump. The third drum, 24 in. x 23 ft. in size, is supplied by an 8-in. connection; it has 5-in. outlets to two additional high-duty elevator pumps, a 2½-in. branch to a duplicate pilot return pump, and an 8-in. connection to an auxiliary supply main from the saturated steam header through the pump section of the engine room at the rear. This drum has blank flanges for connections to possible future generating units for which space is left in the engine room. The two 24-in. drums supply similar equipment and could have been replaced by a single large drum but for obstructions in the basement which prevented its installation. All drums are connected by tie lines to the ends opposite from those for supply, the line being 8 in. in size between the two longer drums with a 5-in. branch to the shorter. The connection to the 23-ft. drum is made into the 8-in. branch to the pump room at a point immediately beyond the valved connection to the drum.

The auxiliary steam piping starts in an 8-in. header having 6-in. branches to the saturated steam nozzles of each boiler. It has an 8-in. connection at one end to the air compressor of the post-office pneumatic tube system, for a duplicate supply, and at the other end is extended as an 8-in. auxiliary main into the pump section of the engine room, where it is connected to the 5-in. extension of the superheated steam line, so that either superheated or saturated steam may be delivered to this auxiliary equipment. The 8-in. line extends thence through an expansion loop to the 8-in. auxiliary main from the large steam drum in the engine room, so as to form through this connection a reserve supply from the boilers to the superheated steam system under the engine room, without the use of duplicated mains. All piping is of steel, with Van Stone joints on all sizes above 5 in., and the entire high pressure system, including piping and receiver drums, was tested to 300 lb. by hydrostatic pressure before use. All of the high-pressure piping is covered with two layers of magnesia sectional covering with canvas jacketing sewed on. Access to the boiler room headers is afforded by an elevated walk suspended between the mains, convenient to all valves and connections.

The exhaust piping system centers in a 20-in. header located on an elevated platform at one corner of the engine room, which receives the exhausts from the engines, pumps and all steam-using machinery. The exhausts from the electric units and elevator pumps are all connected into a single 20-in. line extended from this header, while those from the auxiliary pump equipment are handled by a 10-in. branch to the rear of the engine room. From a point near the inlet to the header, connection is made to a muffler-tank grease-extractor under the raised platform, thence to the feed-water heater and beyond to a low-pressure distributing header from which connections are made the heating mains. The muffler tank is a 54x132-in. Utility combined muffler tank and grease extractor, connected through T-fittings, between which a valve in the main permits of bypassing. The connection to the feed-water heater beyond is also bypassed, and the main beyond the connection to the distributing header has an extension through a back-pressure-valve to an atmospheric relief riser to a roof exhaust head. The distributing header is at the northerly end of the platform and from it two 12-in. and five 10-in. lines are taken off. An eighth connection is for live steam supply to the heating system, consisting of an 8-in. pipe from the superheated steam header which leads through an 8x14-in. Kieley reducing valve.

Electric Units.—There are a 400-kw., a 300-kw. and two 200-kw. Corliss-engine direct-connected units in a well-lighted portion of the engine room under the sidewalk lights. Each consists of a Rice & Sargent Corliss engine, direct-connected to slow-speed multipolar generators. The engines are of the tandem compound type, the largest unit having 18x30x42-in. cylinders, the 300-kw. engine 16x26x42-in. cylinders while the smaller units have 14x22x42-in. cylinders, all operating at 100 r.p.m. They are fitted with reheating receivers, which are located with the connections in the pipe cellar underneath. An interesting feature of the engines is the device on each unit to indicate by means of a pointer and scale approximately the amount of valve opening necessary for the load at any time. This enables the proportion of work done in the high and low pressure cylinders to be adjusted with changes of load to produce a more nearly constant exhaust pressure for the heating system.

The generators are Crocker-Wheeler engine-type direct-current machines wound for the 120-volt two-wire system used in the building. The electric plant is controlled from a thirty-panel switchboard of white marble. Four wide panels are devoted to machine control, two are for power and lighting total panels, and the remaining sections on either side for the power and lighting distribution respectively. A feature of the latter is the use of double-pole circuit breakers instead of the usual knife switches, the latter not being used on any of the feeder circuits at the main switchboard.

Heating System.—The heating of the building is done with exhaust steam from the power plant, using the Webster vacuum system for the return of condensation. Direct radiation is used except where direct-indirect heating is employed for rooms facing the interior court; the ventilating systems for the stores, some of the large offices on the first and second floors, and the basement and sub-basement, are arranged to deliver tempered fresh air only, with the exception of one large room on the second floor in the delivery ducts to which there are reheater coils for partial indirect heating. The direct radiation has been proportioned on the thermal unit basis for warming to 70 deg. Fahr. in zero weather. Radiators are in general of the sectional cast-iron type in both the two and three column patterns, but pipe coils have been used also in various locations, particularly under skylighting. Thermostatic regulation is provided in the stores and in a number of the large offices, and also for the tempering coils of the ventilating systems, but the radiation in a number of offices in the upper floors is under hand control.

For supplying steam to the radiation, six mains extend from the low-pressure distributing header in the engine room to risers in different sections of the building from which the radiation is supplied upon all floors, and a seventh pipe goes to the tempering coils of the ventilating systems. Two mains are 12-in. lines and lead to the two Madison Ave. corners while the remaining five are 10-in. lines. Three of these supply the north central and the two easterly corners of the building, while a fourth supplies the portion of the building on the 23d St. front, and a fifth supplies the tempering coils. The returns are handled by two groups of vacuum pumps, one for the direct radiation and the other for the tempering coils. The former has two Knowles brass-fitted pumps with 12x18x18-in. cylinders which draw from a 10-in. suction header into which six return gathering mains from the direct radiation are connected. The other group has two similar pumps with 10x16x16-in. cylinders, which draw from a similar suction header having return connections from four sets of tempering coils and the special heating coils on the second floor. Each of the return mains to the two suction headers are independently fitted with Webster combination dirt catchers and jet condensers, to condense any vapor which may be drawn through the lines. These pumps discharge into a large open receiving tank on the feed pump platform, from which the boiler feed pumps take suction directly for return to the boilers.

Ventilation.—Mechanical ventilation is provided for the sub-basement, basement, and part of the first and second floors of the building, for which seven Sturtevant centrifugal fans have been installed in the basement. The fans are a 9-ft., two 7 ft. and a 5-ft., with air filters and tempering coils for the fresh air supply in cold weather, three exhausters, a 9-ft., an 8-ft., and a 4½-ft. The 9-ft. blower and 9-ft. exhauster fan, which provide for fresh air for the engine and boiler rooms are coupled together in tandem and driven at 150 r.p.m. by a 45-h.-p. motor. The two 7-ft. fans for the basement, first and second floors are similarly connected and operated by a single 20-h.-p. motor running at 165 r.p.m., and the 5-ft. fan and 4½-ft. exhauster which serve the sub-basement are also mounted in tandem and driven by a 10-h.-p. motor at 250 r.p.m. The 8-ft. exhauster for the first floor and basement is driven by an 18-h.-p. motor at 165 r.p.m. In addition to these there are two Monogram fans, one for cleaning air filter frames, and the other for the removal of fumes from the storage battery room, the latter being of special construction to protect it from the effect of acid gases. All of the fans are driven by C. & C. variable speed motors.

The fresh air for the blowers is cleansed by three sets of cheesecloth filters built into the fresh air intakes in the center of the basement. The filters are of the usual zig-zag type with cheesecloth-covered wooden frames and galvanized netting backing, and provide 1,100 sq. ft. of filtering area for the engine and boiler room, 1,600 sq. ft. for the basement and second floors, and 500 sq. ft. for the sub-basement. For cleaning these filters there is provided in the store room an exhauster with collecting hopper. The frames are placed on the hopper with the intake side of the cloth pointing downward, and the exhauster is started; in this way all dust and dirt are removed, the greater part of which settles in the hopper while the remainder is exhausted out of doors. An exhaust relief bypass, operated by the foot, is provided for relief of the suction in order to permit removing the frames from the cleaning hopper without stopping the exhauster.

The tempering coils of the fresh air systems are designed for warming the maximum amounts of air delivered to the interior temperature of the building, no provisions being made for indirect heating except for several offices on the second floor, as before stated, in the delivery duct to which special heating coils are installed to provide additional heating during occupancy. The tempering coils are of the Sturtevant standard wrought-iron pipe construction with cast-iron bases, and are installed in the intake connections between the fans and filter chambers. There are four coils. Two are in intakes from a common filter chamber to the two 7-ft. blowers, one for the first and second floors and the other for the basement; these together have a total of 1,460 sq. ft. of heating surface. The 9-ft. and 5-ft. blowers have separate tempering coils, of 1,100 and 390 sq. ft. heating surfaces, respectively. The heating coil for the several offices on the second floor consist of a special reheating coil mounted in an enlargement of the duct to this room, and has 425 sq. ft. of surface. All tempering and reheater coils are under automatic temperature control, for which the Johnson system is used. An additional feature of interest is the use of humidifiers in all of the fresh air supply systems. This apparatus is of the Johnson type, consisting of evaporating pans fitted into the bottoms of the connections between the tempering coils and the blowers, which are kept filled with water and contain steam coils for evaporating the water as required. The coils are of copper and are under the control of humidostats in the fan discharge ducts, admitting steam as required to increase or retard the evaporation. This apparatus, like that for temperature control, is entirely automatic and is stated to be very effective in maintaining the proper degree of humidity.

The duct connections are in general in the basement and sub-basement, where branches lead from the various fans to riser ducts concealed in wall chases or in enclosures surrounding the building columns. On the first and second floors, distribution connections are made in furred ceilings to the various wall outlets. Ventilation is arranged on the downward system except for the engine room, in which fresh air is admitted at both the top and bottom of the room while the exhaust connections are all made from the upper portions of the room. The provisions for ventilation on the first and second floors are for the more important of the large offices of the insurance company, which are at times occupied by large numbers of people. Most of the rented offices on the upper floors are provided with exhaust ventilation, operated by disc exhaust fans located in pent houses on the roof, to which the vent flues from the offices are connected by gathering ducts in the attic. In addition, the rooms facing interior courts are also provided with direct-indirect radiators with air inlets from the courts.

The details of the power plant installation and of the heating and ventilating systems were designed by Mr. Alfred R. Wolff, consulting engineer, New York. The contractors for the installation of the equipment were Baker, Smith & Co., New York. The architects are Messrs. N. LeBrun & Sons, New York.

The Marlborough Apartment House, Baltimore, Md.

The 169x129-ft. ten-story Marlborough Apartment House on Eutaw St., in Baltimore, is one of the largest structures of its class in the city, and was designed with special attention to permanent and fireproof construction. It has a concrete skeleton and brick exterior walls supported on the reinforced-concrete floors. It is U-shaped in plan with two wings 53½ ft. wide which, together with the connecting part of the building, enclose three sides of a 75x56-ft. light court. It has 100-ft. columns from 7 to 16½ ft. apart on centres, which are located in the exterior walls in the corridor partitions and intermediately in irregular positions, causing considerable irregularity in the floor girders only part of which are connected directly to the columns.

The floors are proportioned for a live load of 60 lb. per square foot plus the dead load, and the roof, which is intended to be used for a garden, is proportioned for a live load of 60 lb. per square foot, the columns being calculated to take the sum of all the maximum floor loads without the diminution sometimes allowed for lower stories. The concrete in the beams, girders and floor slabs is calculated for an average compression stress of 350 lb. per square inch and the reinforcement steel is figured at 16,000 lb. tension per square inch.

The floor slabs, 4 in. thick, are reinforced with two crossed courses of rods ⅜ in. in diameter and about 9 in. apart on centers, which extend across the adjacent beams and girders and have their ends bent vertically downwards to provide anchorages. The floor slabs in all eight panels on the Eutaw St. ends of the wings and in four other panels in the court faces of the wings, besides six interior panels of the building, are provided with single ½-in. horizontal diagonal rods reaching from center to center of the floor beams bounding the panel which they cross, and are anchored with bent ends in the slabs of the adjacent floor panels, thus providing a system of tension kneebraces to resist lateral stresses from wind pressure.

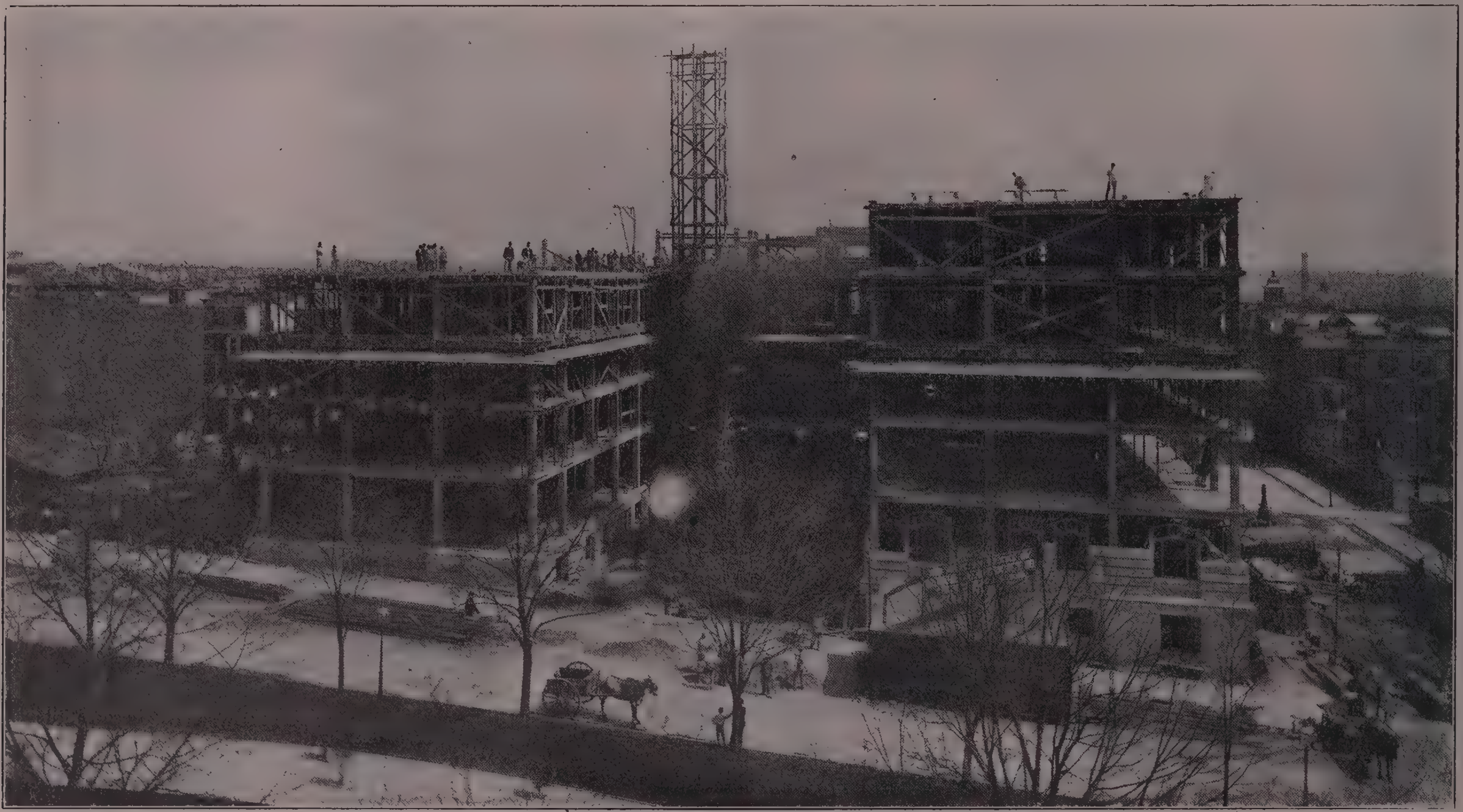
On the northwest and southeast sides of the building, there are two bay windows 10 ft. wide, which project 3 ft. beyond the exterior walls and have floors made with cantilever extensions integral with the main floor slab. These cantilevers are reinforced by projections of the transverse rods in the floor and have the thickness of concrete reduced to 3 in. at the outer edge of the slab. The beams and girders are all of rectangular cross-section, and in general their dimensions are respectively 6x10 in. and 8x12 in. for the interior beams and for the wall girders. They are constructed with special double reinforcement stirrups like those in the Washington Apartment House described in The Engineering Record recently.

The columns are made in one-story sections and are uniformly 10 in. square in the tenth story, where they are reinforced by four ⅝-in. rods tied together horizontally with No. 3 wire 10 in. apart. The dimensions and reinforcement of the columns increase downwards to a maximum of 14x14 in. with eight 1¾-in. rods in the basement. The wall girders are made with their outer faces flush with the outer faces of the wall columns and support the brick wall built on them in one-story sections, which overhang the outer edges of the beams 6 in. The walls of the bow windows in the rear are of reinforced concrete 5 in. thick and cement finished outside so as to match the color of the brick.

The building is symmetrical about the transverse center line, and consequently general drawings had to be made of but one-half of each floor plan, on which every beam, girder, floor slab and column was indicated by reference letters and numbers. For example, the floor slabs in the panels adjacent to Eutaw St. are marked A-1, A-2, A-3, while those in the center of the same wing are marked L-3, L-3, L-3, L-3 and so on. The floorbeams and girders all have consecutive numbers without letters, and detail drawings and bills of reinforcement steel are made for each member. The column schedule is written on a diagram which has elevations and cross-sections of the six different sizes of columns required and shows the heights of the stories, dimensions and sizes of reinforcement bars. These and the standard and special detail drawings cover all features of the design and provide very simple and comprehensive data from which estimates are made, material ordered and all work in the field constructed and checked.

The 1:2½:5 concrete was made with Alpha or Northampton Portland cement mixed with broken granite in a Smith machine located in the court. It was handled on wheelbarrows to two platform elevators running side by side in a falsework tower built at the outset to the full height of the building. Each platform carried two wheelbarrows and was operated at a high speed. The wheelbarrows were run on top of the floor molds or the finished concrete and did not require to be wheeled more than about 100 ft. maximum. Four complete sets of floor and column molds were provided at the outset, and were nailed solidly together so that when removed it was necessary to take them wholly apart and afterwards fit and renail them for use in the upper stories. About 190,000 ft. B. M. of lumber was required for the molds and falsework for the 4,500 cu. yd. of concrete, which was reinforced with about 400 tons of steel.

The building was commenced in March, 1906, and was finished in the following June by an average force of about 100 men, including 40 carpenters. Reinforcement steel was hoisted by a line operated from the capstan head of the double-drum engine installed for the elevator service, thus handling it without additional expense. The forms were not stripped from the concrete until the latter was at least 25 days old, and whenever it was deemed necessary, the centers of the beams and girders were temporarily supported by vertical shores after the remainder of the falsework was removed. The brick walls were commenced after the concrete wall girders were 30 days old and were built up from the bottom to the top in regular succession, the bricklayers working on platforms supported by cantilevers projecting from the windows and reacting against vertical struts at the inner end bearing on the girders in the floors above.



Views Showing the Marlborough Apartment House, Baltimore, in Course of Construction.

Mr. E. H. Glidden was the architect of the building and the engineers and contractors were the Baltimore Ferro-Concrete Co., Mr. H. J. West, president; Mr. Henri Kampmann, engineer and treasurer.

Peat Fuel Manufacture in New Jersey.

The peat fuel works of the American Peat Coal Co. at Lincoln Park, N. J., comprise a 35x100-ft. main building and two drying houses. The peat is from 3 to 10 ft. deep in this vicinity and of a brownish-black, fibrous quality. It is dug by hand by means of a shovel of special form, known as a slane, and the pit from which it is taken has to be drained by a steam pump. It is conveyed from the pit in steel cars to bins in the second story of the main building, which contains a 50-h.-p. steam plant, a Heinen briquetting machine and minor equipment. The machine has a rated capacity of 50 tons of bricks daily, and consists of two breakers. In the first the peat is roughly broken and in the second it is kneaded into a plastic mass which is forced through a die in the form of a bar measuring 9x4½ in. This is cut into two bars 4½ in. square, which are cut by hand into short lengths and then taken by a conveyor to the drying houses. The larger of these has shelving sufficient for 1,000 tons of briquettes, which are kept there for two to four days, during which they become air-dried into hard masses, which are stored in bins. The smaller house can be heated by steam and the drying accelerated in this way.

Tower Derricks at the Washington Municipal Building.

The steel framework of the Municipal Building in Washington, D. C., was erected by a pair of tower derricks of special construction. Each had a steel tower about 30 ft. high and 15 ft. wide at the base, with a bearing at the top for the middle of the derrick mast, which projected below it to a second bearing engaging its foot in the axis of the tower. The upper part of the mast projected through the horizontal boom, and the latter was rigidly attached to it and supported at both ends and intermediately by steel back stays to the top of the mast. A trolley hoist running on the boom was raised, lowered and traversed by the double-drum hoisting engine, which was also provided with a swinging device to revolve the boom by means of a bull-wheel connected to the mast at the top of the tower. The rear end of the boom had a scale-pan counterweighted to balance the live load on the opposite end of the boom.

The towers were jacked up from tier to tier as the erection of the building progressed, and were so located that their booms commanded the whole structure except a portion served by stiff leg derricks. They were found very rapid and efficient and had the advantage of independent stability and freedom from guys or braces. The boom could revolve 360 deg. and the work was unobstructed except for the small area occupied by the tower. These derricks were an improvement on a similar wooden derrick with a 75-ft. tower originally built about three years ago for the removal of an old building in a crowded street, where the structure itself was not considered strong enough to sustain the derricks. In order to make them independent of the building, their towers were carried through holes in the different floors and seated on the ground. The derrick was patented by Mr. James L. Parsons, Washington.

The Concrete Arches lining the bins of the tower of the Waterside Station, described last week, are Clinton, not Roebling, construction, as wrongly stated.

Progress in Electrification of Steam Roads.

At the International Electrical Congress of 1904, Mr. B. J. Arnold ventured the opinion that electrification of steam roads would probably begin with the terminals. In addition, "those roads which run through populous countries will either build new roads or acquire as a protective measure the electric roads already built and competing with them." These roads, he stated, would be used as feeders, and, with the electrified terminals, would demonstrate the advantages of electric traction and its desirability for main line operation. At the time these statements were made, the officials of steam railways had paid little attention to electricity, although the inroads of interurban lines were felt in some sections. Since the Congress, the progress of electrification has been very rapid, and it is not surprising, therefore, that Mr. Arnold has again chosen it as the subject for an address, this time before the Western Society of Engineers. Although much of the ground covered has already been gone over in elaborate articles in The Engineering Record, the following extracts from the address furnish in concise form a general statement of present conditions in the electrification of steam roads, valuable in itself and interesting as a proof of Mr. Arnold's prophetic instinct.

Tower Derrick used in Erection of Municipal Building, Washington, D. C.

New York Central & Hudson River R. R. Co.—As is well known, the New York Central & Hudson River R. R. Co. has been engaged in the electrification of its New York terminal for about four years. It has recently put into operation for passenger service interurban trains running between New York City and Yonkers, a distance of 14 miles, and is now introducing electric locomotives into the terminal service for operation of its through trains, between the Grand Central terminal and Croton, 35 miles, and North White Plains, on the Harlem division, 29 miles, from New York. The installation will, when completed, consist of two power stations of 30,000 kw. each and eight sub-stations which will supply and distribute electrical energy to about 400 miles of track within a radius of 40 miles from the city of New York. An experimental track for testing the locomotives designed for this special work was equipped by the New York Central and the General Electric Companies, acting jointly, and upon this track experiments have been conducted for the past three years, with the result that the type of locomotive for through train service which is now being introduced into actual work has, by a long series of experiments, proved itself capable of doing the work for which it is intended. Thirty-five of these machines are now ready for operation, and will be introduced as rapidly as men can be trained to operate them. Each locomotive weighs 100 tons, has a normal capacity of 2,200 h.-p. and a maximum capacity of 3,000 h.-p., and will run at speeds varying from 40 to 80 miles per hour, depending upon the weight of the trains, which will vary from 250 to 900 tons. Two or more locomotives can be coupled together for heavy train service and operated upon the multiple unit system.

Two hundred steel motor cars will soon be placed in suburban service, each equipped with 400 h.-p. of motor capacity, and so arranged that they can be run singly or coupled, on the multiple system, although some are now used as trailers without motor equipments. Each motor car is 60 ft. long over all, weighs 53 tons, seats 60 passengers, and is designed to run at a maximum speed of 52 miles per hour.

One power house, in which has been installed 20,000 kw. in turbo-generators and the necessary auxiliaries, is now in service, and the energy distributed to the trains by means of four substations, in which are placed storage battery auxiliaries for the purpose of regulating the load upon the power stations, and for reserve capacity in case of accident to any substation or power station. From the substations the energy is distributed to the trains by means of secondary copper feeders and the inverted, or under-contact, type of third rail.

By the adoption of electric traction, the New York Central Company was able to abandon the use of steam locomotives in its Park Avenue tunnel, which has always been a source of annoyance to its patrons and of danger to the road. It has also been enabled to make extensive improvements in its terminal facilities in the way of lowering its tracks, thereby making the viaducts leading from the western part of the city to the east side available for team traffic, thus adding greatly to the value of east side real estate, this condition of lowering the viaducts having been imposed upon the company by the city before the road could obtain permission to make the improvement. With this condition imposed upon it, however, the company saw fit to acquire a large amount of additional real estate on each side of the right of way, which permitted its engineers and architects to plan a much more comprehensive terminal than had been previously possible. This terminal station will cost approximately $15,000,000 when completed, and will be built upon the double deck plan, the suburban trains entering it at the lower level and the express trains on the upper level. The introduction of electric traction into this terminal has made it practicable for the company to expend advantageously about $65,000,000 in these terminal improvements, about $15,000,000 of which was for the electric traction portion of the equipment.

Pennsylvania R. R.—Beginning at Bergen Hill in New Jersey, about 2.7 miles from the proposed New York City station and almost directly in line with 33rd St. on Manhattan Island, the plans of the Pennsylvania R. R. contemplate the construction of two tunnels, each 19 ft. in diameter, parallel with each other, from Bergen Hill, through the Palisades, and under the Hudson River, thence under a portion of Manhattan Island to the terminal station located between 32nd and 34th Sts. and 7th and 8th Aves. in New York City. From this terminal station eastward there will be four tunnels, each 23 ft. in diameter, extending across the Island under the East River to the terminal in Long Island City, where the tracks will come to the surface, and connect with the extensive yard contemplated by the Pennsylvania system at that point. Through these tunnels, which are about 14,000 ft. in length, will be operated by electric locomotives all passenger service of the Pennsylvania R. R. entering New York City, and probably a large amount of freight for the distribution yard at Long Island City. The suburban trains for interurban service passing through these tunnels will be operated on the multiple unit system, and the electric locomotives will be, as in the case of the New York Central, similarly operated when it is desired to couple them together.

Hudson and Manhattan Tunnels.—For the purpose of enabling the interurban and other steam roads entering Jersey City to enter the city of New York, there are now being constructed two other systems of tunnels, one under the name of the Hudson & Manhattan R. R., and the other under the name of the New York & New Jersey R. R. The interests of both companies have been recently consolidated and now operate under the name of the former. The two tunnels of the Hudson & Manhattan Co. extend from the foot of Exchange Place in Jersey City to a terminal at Church and Fulton Sts., in the Island of Manhattan, a distance of about 9,000 ft. The tunnels of the New York & New Jersey R. R. Co. will extend from the foot of 14th St., in Jersey City, to Morton St., on Manhattan Island, a distance of about 5,000 ft.

It will be noticed that the tunnels of both of these companies are considerably smaller than those of the Pennsylvania Co. They are constructed for the purpose of feeding the present subway of the Interborough Rapid Transit Co., consequently all cars entering these tunnels will have to be of the special small and low design, with third-rail direct-current equipment substantially like that now used by the Interborough Co., a misfortune which it seems impossible now to overcome, as it will effectually prevent any of the through trains of the steam roads which now terminate at Jersey City entering Manhattan Island unless they come through tunnels of their own to be hereafter constructed.

East River Tunnels.—In addition to the subways heretofore mentioned, to be used for the accommodation of steam railway traffic, there are to be four additional tunnels constructed under the East River, two by the New York & Long Island R. R. Co., at 42nd St., and two under the direction of the Rapid Transit Commission, from the present terminal of the Interborough subway at the Battery to Joralemon St., in Brooklyn, connecting with the subway under construction to the Flatbush terminal of the Long Island R. R.

It will thus be seen that when the present tunnels which are now under construction are completed there will be six under the Hudson River, and eight under the East River, or fourteen in all.

New York, New Haven & Hartford R. R.—The decision of the New York Central R. R. Co. to adopt electricity for its terminal necessitated similar action on the part of the New York, New Haven & Hartford R. R., as the trains of the latter company enter the Grand Central Station over the tracks of the former. The New Haven company not having taken up the subject until some two years after the decisions of the Central was made, and having the benefit of the development in the state of the art, decided not to adopt the direct-current, third-rail method of propulsion, but on the contrary adopted the single-phase overhead contact method of train propulsion, and is now engaged in installing and getting ready for operation the most extensive and elaborate single-phase system yet attempted, the outcome of which is being watched with great interest by railroad men.

This company is at present installing electric traction on its system between Woodlawn, where its tracks join those of the New York Central Co., and Stamford, Conn., 33 miles from New York. Between Woodlawn and Stamford the road will be equipped with an overhead working conductor, operating with single-phase, 25-cycle current at 11,000 volts. From this conductor the current will be collected by means of under-contact sliding shoes, transformed to a pressure of about 450 volts by the transformers carried upon the locomotives, and used in the motors as alternating current. Each locomotive will be designed to weigh 72 tons, has a nominal capacity of 1,000 h.-p., and is designed to make 26 to 45 miles per hour, with trains varying from 200 to 250 tons. Several of these locomotives have been delivered and are now being tried out on the experimental tracks of the company; it is expected that they will go into practical service as soon as the overhead work and power station equipment of the company can be completed. The company will not at present use the multiple unit system, but will operate its suburban trains by means of these electric locomotives, 30 of which have been ordered for this service. The system will be operated from the company's power station, generating single-phase current, and having a capacity sufficient to properly operate the trains. The overhead construction is divided in sections with suitable circuit breakers at the end of each section, which will open automatically in case of a short circuit or can be manually controlled by the towermen.

St. Clair Tunnel.—In order to eliminate the present objections regarding the use of steam locomotives in the St. Clair tunnel of the Grand Trunk Ry., extending between Port Huron, Mich., and Sarnia, Ont., the officials of that company decided a little over a year ago to adopt electrical propulsion. After due consideration it was decided to adopt the single-phase method of propulsion. This system was adopted for several reasons, the principal one being the objection to the use of the third rail in the yard of the company at each end of the tunnel, which was quite extensive, and in which much switching had to be done in making up trains before entering the tunnel. The equipment will consist of six electric locomotives, weighing 120 tons each, having a normal capacity of 1,500 h.-p., capable of exerting a drawbar pull of 25,000 lb., at a speed of 10 miles per hour, and a maximum speed for passenger train service of 35 miles per hour.

The power station, which is now well under construction, will contain two 1,250-kw., turbo-generators, either one of which will be capable of operating the tunnel up to its full capacity, the other being held in reserve. The decision to adopt single-phase for this installation was made by Mr. Arnold some time prior to the decision of the New Haven Co., and like it, the working of this system in this class of service will be carefully watched.

Erie Railroad.—The Erie R. R. Co. has a commission organized for the purpose of electrically equipping its lines running out of Jersey City, a total of about 250 miles, although it is contemplated that but 35 miles will be immediately equipped, viz., the division extending from Jersey City to Greenwood Lake. In addition to its suburban lines in the vicinity of Jersey City and its terminal, the road now has under construction 34 miles of single track, known as the Rochester Division. This division lies between Rochester and Avon, N. Y., with a branch between Avon and Mt. Morris. The single-phase, alternating-current system will be used, having a working pressure of 11,000 volts on the overhead conductor. The energy will be secured from Niagara Falls at a pressure of 60,000 volts. Six passenger coaches, 54 ft. long, and seating 56 people, will be placed in service, each car weighing about 50 tons and equipped with four 100-h.-p. motors. These cars will be capable of a maximum speed of 45 to 50 miles per hour, and of hauling one trailer. While this extension of the Erie system is short, the company has under contemplation the electrical equipment of its entire suburban service surrounding Jersey City, which will involve an expenditure of some $15,000,000. Plans are now being formulated for this expenditure.

West Jersey and Seashore Branch.—This is a recently electrified branch of the Pennsylvania R. R. from Camden to Atlantic City, N. J., a distance of 65 miles. Equipment consists of a power house, 8 sub-stations, and 71 miles of duplicate high-tension line. The service is ultimately to consist of three-car express trains running 60 miles per hour on a 15-minute headway, and local service at 10-minute intervals. The equipment of this line was done in record-breaking time, the site for the power house having been chosen Jan. 17, 1906, and on July 1 two boilers were under steam with a turbine and auxiliaries running, and car service on the line.

In the sub-stations the line voltage is reduced and transformed from 33,000 volts, 3-phase, to 650 volts direct current. Third rail equipment was used of Pennsylvania R. R. standard dimensions. These dimensions will satisfactorily operate with equipment of the Long Island R. R. and the Interborough system of Manhattan Island. The rail is protected at stations and in yards. The cars for service on this line have a seating capacity of 58, are double vestibuled, and are well protected from fire risk. The cars are 55 ft 5½ in. long, and weigh, when fully equipped, 89,000 lb., being heated and lighted electrically, and equipped with hand brakes and quick service air brakes.

Southern Pacific Ry.—The Southern Pacific Co. is making active preparations to change about 20 miles of local steam line near San Francisco for electric traction service. The line extends from the ferry terminal to Alameda and Oakland, with the generator station at Alameda Point. The electrical equipment is built for 500 volts direct current, with overhead trolley and utilizing present tracks. A year has been allowed for this work to be completed, after which time the electrification of the lines may possibly be extended. It is not the intention at present to do away with the steam locomotives, but these will be used to aid the electric service during the rush hours. It is stated that an appropriation of about $1,250,000 has been made for this work.

West Shore R. R.—An important piece of equipment for electrical operation is now under construction by the West Shore R. R. between Utica and Syracuse, N. Y. The work in hand covers a distance of 44 miles, and the passenger schedule provides for limited trains in each direction, making the distance from terminal to terminal in 1 hour and 22 minutes. In deciding upon the plans, the relative merits of alternating current overhead equipment and third-rail direct-current equipment were carefully considered, and the decision to install the direct-current system was largely determined by the general flexibility of a third-rail equipment should it become desirable to make lateral extensions, install additions, side tracks, etc.

Over certain sections of the line traffic conditions require that two additional tracks be built. These tracks will enable the passenger trains operated electrically at 55 and 45 miles an hour to avoid interference with freight trains operated by steam, fast freight trains with a schedule of about 25 miles per hour, and local freights with a schedule of about 15 miles per hour.

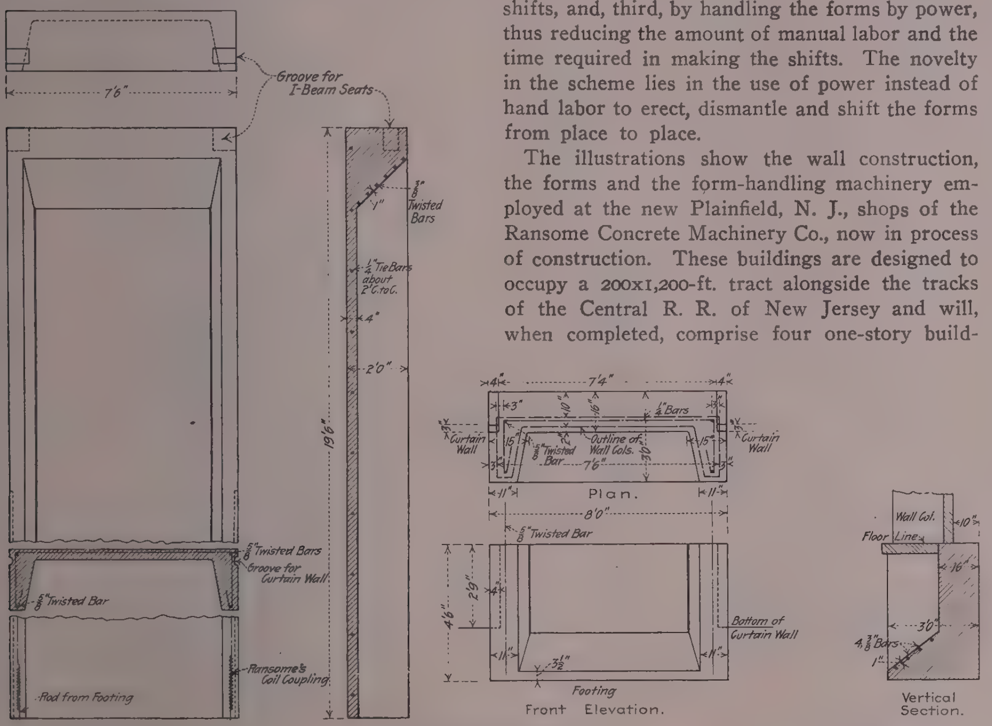
Construction work was started on May 15, and is well under way at the present time. Electric power will be furnished by the Hudson River Electric Power Co., which will deliver three-phase, 60,000-volt current at the railway company's sub-station 7 miles west of Utica. The Hudson River Co. will for the present generate this current at its auxiliary steam plant in Utica, but upon the completion of its contemplated transmission lines, current will very likely be taken from the hydro-electric plants owned by the company in the eastern part of the state. There will be four sub-stations located about 10½ miles apart. These will be identical in construction and each will be equipped with two 300-kw. rotaries and necessary apparatus for transforming 60,000-volt, three-phase current to direct current for distribution to the rails at 600 volts.

The third rail construction is the Wilgus under-running protected type, this being the standard adopted by the New York Central Co. The rail is protected for the greater part of the distance by 1¼-in. wood planks above the rail, and on both sides, and part of the line has a rail protection of indurated fiber 3/16 in. thick, molded to conform with the rail section. The third rail is located between the parallel tracks except where curves or other special conditions require it to be transferred to other sides of the track.

The company will operate 15 closed cars, 49 ft. over the bumpers, each equipped with four 75-h.-p. motors per car, and multiple unit control.

Spokane & Inland Ry.—This is a single-phase line between Spokane, Wash., and neighboring cities, having a total mileage of 114. The capital invested in the project is approximately $3,500,000. The service includes passenger, mail, express and carload freight. The power is purchased from the Washington Water Power Co. and is delivered to the railway company as three-phase, 60-cycle current to a frequency changing station 10 miles south of Spokane. This station has four frequency changers, each of 1,000 h.-p. nominal capacity, which convert the current to 25-cycle, 2,200-volt, single-phase current. For transmission to the sub-stations, this 2,200-volt current is stepped up to 45,000 volts and transmitted to fifteen sub-stations, where it is stepped down to 6,600 volts for direct connection to the trolley circuits.

The cars and locomotives operate on three different voltages at different parts of the line. In the country 6,600-volt alternating current is used, and in the smaller towns 700-volt alternating current, while within the limits of Spokane 600-volt direct current is used. In the country and through the small towns a pantagraph under-running trolley is utilized, while in Spokane the ordinary under-running trolley wheel is used. The passage from the alternating-current to the direct-current system is done by operating a commutating switch, which makes all necessary connections, and by changing the trolley from the pantagraph to the wheel type.



Wall Column.

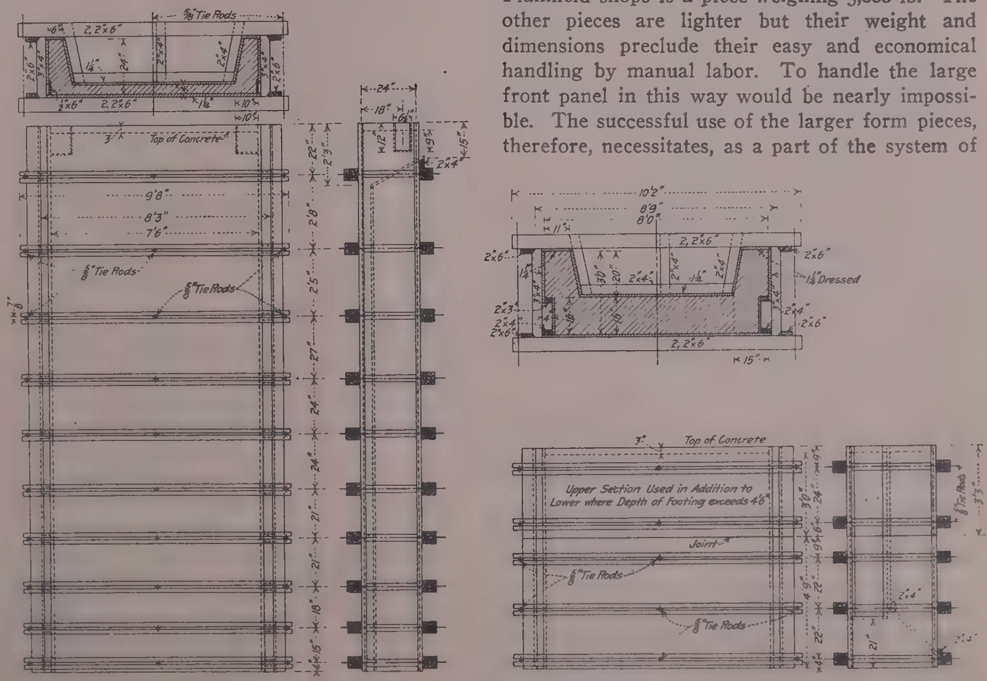
The cars are equipped with four 100-h.-p., alternating-current motors. The locomotive uses the same type of motors but have a capacity of 150 h.-p. each. Both the locomotives and coaches may be operated on the multiple-unit system. The locomotives are capable of handling 7 standard freight cars, fully loaded, at 30 miles per hour, on level track. This locomotive weighs 49 tons and has a length over the bumpers of 29 ft.

IRON AND STEEL PRODUCTION in the United States, which now leads the world in the output of these metals, was recently discussed at length by the London "Economist." In the last seven years, it is stated, the increase in consumption of iron and steel has averaged over 7 per cent. annually, whereas in the eleven preceding years it was but about 4½ per cent. The great percentage increase during the last seven years has been due to the expansion of the iron and steel industry in the United States, which has been at an average rate of 11 per cent. annually. "When it is remembered that the United States' exports in 1906 will probably show less than 5 per cent. of the whole production, we can then understand the enormous home consumption of that country, but it is well known that it has for some time enjoyed a prosperity beyond all precedent."

A Special Reinforced Concrete Shop Wall.

The accompanying illustrations show a type of standard factory wall construction in reinforced concrete that has been found in actual practice to effect a material saving in the cost of form-work as compared with other designs. This construction is based on the reasoning that economy in wall form-work must be sought, first, by the use of movable forms, which can be shifted as the work progresses and used over and over; second, by the use of as large form units as possible, thus reducing the number and the frequency of the shifts, and, third, by handling the forms by power, thus reducing the amount of manual labor and the time required in making the shifts. The novelty in the scheme lies in the use of power instead of hand labor to erect, dismantle and shift the forms from place to place.

The illustrations show the wall construction, the forms and the form-handling machinery employed at the new Plainfield, N. J., shops of the Ransome Concrete Machinery Co., now in process of construction. These buildings are designed to occupy a 200x1,200-ft. tract alongside the tracks of the Central R. R. of New Jersey and will, when completed, comprise four one-story buildings ranging from 500 to 600 ft. in length and from 50 to 60 ft. in width, with a 50x70-ft. central power plant and several smaller buildings. Work is now in progress on the power house and on the first of the main shops, 592 ft. long and 53 ft. wide. As the design of all four main buildings is the same, a description of the one now under construction will suffice for all.



Sectional Form for Wall Column.

Briefly, the wall construction consists of a row of broad channel-shaped columns filled between with curtain walls and with windows, and carrying steel roof trusses spanning the shop space. Practically speaking, the footing is a separate construction from the column, but theoretically the two form a single member and act together as such. The drawings need very little explanation. The columns are arranged with the backs of the channel outward and are just as wide, 7½ ft., as the space between them; they make up, therefore, half of the exterior wall area, the other half being composed of the low curtain walls and the window areas. At the tops of the columns the space between flanges of the channel is filled solid with concrete, forming a bracket girder reinforced on the bottom face. The ends of these girders are molded with pockets to receive the ends of I-beams spanning the space between columns and forming, with the bracket girders, continuous runway girders for bridge crane tracks.

The wall construction, so far as the concrete work goes, consists of three parts only, namely the column footing, the columns, and the curtain wall slabs. In a word, one form would suffice for molding all the footings, another for molding all the columns, and a third for molding all the curtain slabs. Of course this extreme reduction of form-work is not practicable, but it is a fact that in molding the eighty footings and columns and the seventy-eight curtain wall slabs, only ten forms of each kind have been used. In other words, each form was used eight times and was shifted seven times.

As for the form construction, special mention need be made only of the column form proper. This consists of four pieces, the back and the two sides, which are plain panels, and the front, which is a trough-shaped panel forming the channel space and the edges of the flanges. Battens across the front and back panels with slotted ends provide for assembling the four pieces by means of tie bolts. The feature to be noted in these forms is the sizes of the individual pieces or units. For example, the trough-shaped front panel for the Plainfield shops is a piece weighing 5,000 lb. The other pieces are lighter but their weight and dimensions preclude their easy and economical handling by manual labor. To handle the large front panel in this way would be nearly impossible. The successful use of the larger form pieces, therefore, necessitates, as a part of the system of wall construction here described, suitable machinery for handling the forms.

The device used consists of a light, rigid A-frame mast, 30 ft. high, mounted on one wheel at each end of its 16-ft. sill and carrying an electric crab. In operation the A-frame is mounted on a plank runway laid parallel to the row of columns being constructed and inside the building. About 50 ft. to the rear of this runway and parallel to it a horizontal wire rope is stretched between two deadmen. A similarly arranged rope is located about 50 ft. in front of the runway. These ropes reach the length of ten or a dozen panels of the building. Their purpose is to form anchors for the guy ropes, one leading forward and one backward from the top of the A-frame; they save the necessity of placing deadmen for each move of the hoist, since the guy ropes have merely to be slacked off and slipped along the wire rope anchor while the hoist is being shifted and then made taut when the shift has been completed.

To remove the form from a complete column, the A-frame is set directly in front of it and tilted so that the top of its mast comes vertically over the column. The tackle is fastened first to the back panel, and the tie bolts connecting the four panels of the form are loosened and disengaged. Two men at the top of the column and two at the bottom, provided with bars and aided by an occasional tug of the hoist, loosen the panel, which is then lowered to the ground by the hoist. The side panels are next pried loose and, being comparatively light, are lowered by hand. The front panel, forming the channel, is next removed in exactly the same way as was the rear panel. Its shape, however, makes the removal of this panel more difficult than the removal of the plain back panel. At Plainfield about 30 minutes were consumed in shifting the A-frame and removing the form from a column, working five men, including the crabman.

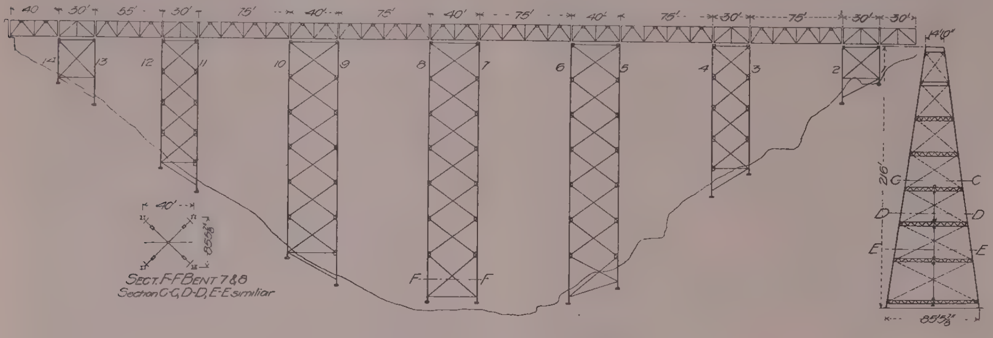
The erection of the column forms is accomplished by practically reversing the process of taking them down, as just described. In constructing the bases the forms are carefully set so that the top is a fairly level, plain surface. Before the column forms are set, however, the tops are leveled up accurately by a layer of mortar shaped by a special form so as to make a tenon of just the shape and dimensions of the bottom of the column proper. The bottom of the column form sets over this tenon, which, being accurately lined up, leveled and centered, fixes accurately the position of the column form at the bottom. There remains, then, only the plumbing of the column form to be accomplished. This is done by any convenient means, after which the form is guyed firmly by steel wires. At the Plainfield shops the practice is to construct the columns in groups alternately on one side and then on the other.

For mixing the concrete a No. 2 Ransome mixer was installed; 1:3:5 slag concrete mixed very wet was used and was delivered from the mixer to the work in Ransome concrete carts. The work is an interesting example of the latest practice in reinforced concrete building work in systematizing operations and in working out special plant and machinery for reducing the always expensive item of forms and increasing the rapidity of erection.

The Harvey Canal Locks have been completed, and in a short time this waterway will be opened between the Mississippi at Algiers and the rich sugar, rice and gardening lands about Lafourche. It has been built by private capital.

The Las Vacas Viaduct on the Guatemala Railway.

The Las Vacas viaduct is a single-track 3-ft. gauge structure 743 ft. long between back walls and 229 ft. high from the top of the lowest pier to subgrade. The design was selected after making several other preliminary studies of different arrangements and dimensions of spans and towers, as described on Dec. 8, 1906. It consists of seven 30 and 40-ft. towers supporting tower spans of the same length, and eight end and intermediate spans of 30, 40, 55 and 75 ft., as indicated in the general diagram. All spans are made of pairs of riveted trusses with a uniform depth of 12 ft. and a spacing of 10 ft. center to center. They are provided with zigzag top and bottom lateral bracing and with transverse swaybrace frames at the ends and at intermediate panels.

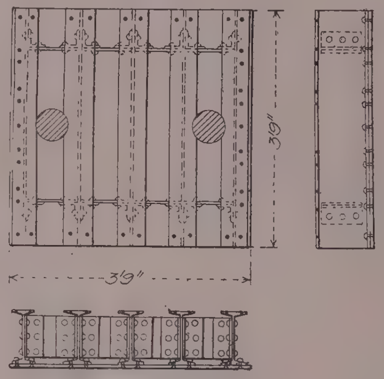


General Diagram of Viaduct.

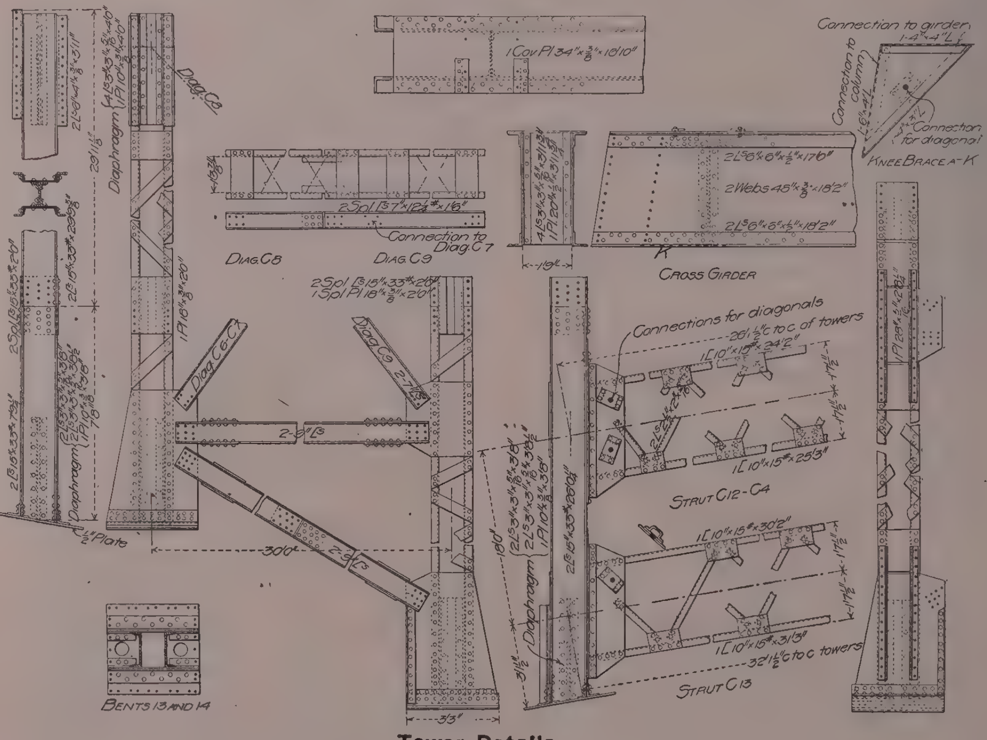
Each tower has two vertical transverse bents, each having two posts 14 ft. 10 in. apart on centers at the top and battered 1:6, giving them maximum widths of 87 ft. for a height of 216 ft. The bents are built in vertical stories or panels, which are not made of uniform height in the upper story and vary from top to bottom from about 18 ft. to 34 ft. The horizontal transverse braces are deep latticed struts and the diagonal members are pin-connected tension rods. The pairs of bents in each tower are braced together by top and bottom longitudinal struts and by a system of X-bracing without intermediate horizontal struts, corresponding to the panels of transverse bracing. Both batter posts in the same bent are always of the same length, but the two bents in the same tower generally differ in length, thus causing the lower longitudinal struts to be more or less steeply inclined except in the middle tower, where they happen to be horizontal, the two transverse bents of this tower together with one of an adjacent tower being of the same length.

In all towers, the feet of the main posts are connected by intersecting tension diagonals made of 1-in. round rods with sleeve-nut adjustments and clevices attached to horizontal connection plates riveted to the longitudinal transverse struts. In the tallest towers corresponding horizontal diagonals are also provided in horizontal planes at the tops of the second, third and fourth panels, and the corresponding transverse struts are also stiffened by longitudinal struts connecting their center points. The centers of the lower transverse struts are supported from the intersections of the diagonal rods above them by vertical hanger rods, pin-connected at both ends. All trusses are seated on the top flanges of transverse plate girders connecting the tops of the tower columns. Both ends of each tower truss and one end of each intermediate truss is free to expand and contract on a sliding seat on the tower girder.

The sub-structures consists of separate pyramidal concrete pedestals under each tower post, which were carried down a few feet to a bearing on rock. The loads are distributed over them through grillages 39 in., 42 in., and 45 in. square. They are made, as shown in the detail sketch, with 9 and 10-in. I-beams having their webs connected by two lines of riveted transverse vertical



Grillage for Columns.



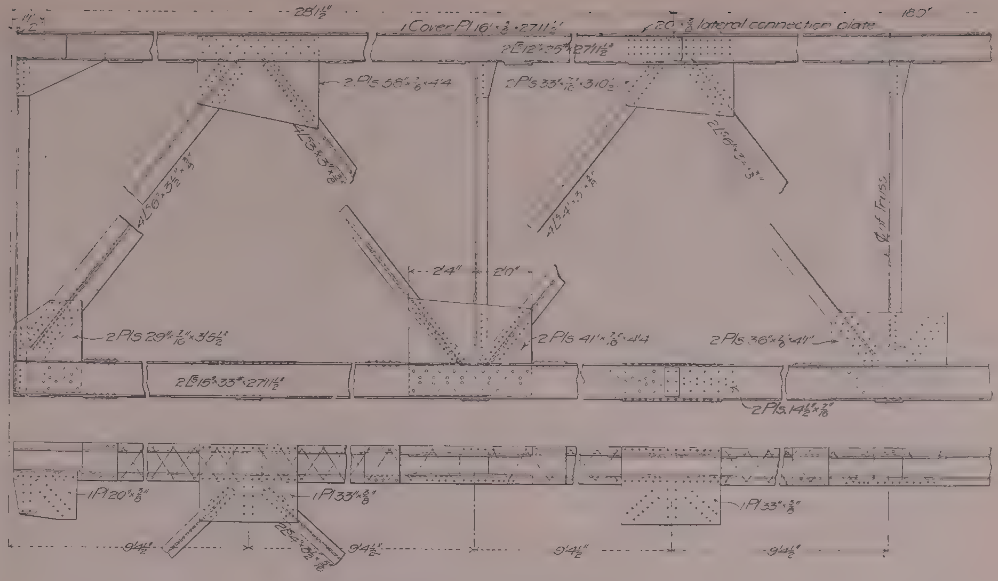
Tower Details.

diaphragms and their lower flanges countersunk-riveted to ½-in. sole plates seated on 1-in. plates through both of which 6-in. holes are provided to permit adjustment for the 2-in. vertical anchor rods that engage angles bedded in the bases of the piers. The upper ends of these rods pass through the grillages and the column bases, and engage bearing washers seated on the latter. The washers are pairs of 4-in. channels 12 in. long with slotted cover plates riveted to their top flanges, so that a 4-in. adjustment is provided by the slot in the direction of one co-ordinate, and by the sliding of the washer at right angles to it.

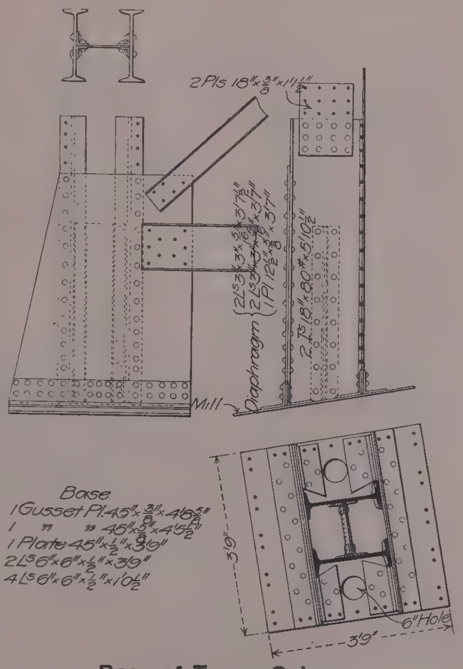
The tower columns are of two types, those at the ends of the viaducts being subjected to the least wind stress, have ordinary cross-sections composed of two 15-in. channels with their flanges turned out and latticed. The webs are transverse to the axis of the viaduct and are connected at panel points by riveted diaphragms. All connections to transverse braces are made through the flanges of the channels, and the connections for the longitudinal braces are made through separate tie plates both shop and field riveted across the column flanges. The extended base plates are stiffened by the long bottom tie plates projecting beyond the flanges and serving as vertical diaphragms or webs to distribute the pressure over the base plates.

At the upper ends of the columns, vertical connection angles are shop-riveted to the channel flanges with open holes in their outstanding flanges to receive the field-riveted connections of the transverse girders. The column joints are made with milled ends and spliced with flange plates and inside web channels, one of the former and both of the latter being shop-riveted to the lower section of the column, while the other splice plate is shop-riveted to the upper section of the column. The longitudinal X-braces are pairs of 7-in. channels latticed together back to back and having their webs field-riveted to the connection plates projecting from the flanges of the columns. One member is continuous and the other is cut to clear and is spliced across it with short field-riveted inside web channels.

The transverse struts are lattice girders 39 in. deep on centers, made of single 10-in. channels for the top and bottom chords and pairs of zigzag 2½-in. angles for the web members. They have end flanges field-riveted to the flanges of the tower posts and provided with horizontal pins through the end tie plates to receive the loop ends of the diagonal rods. The transverse girders connecting the tops of the columns are 48 in. deep with two ⅜-in. webs, one of which is field-riveted across each face of the tower post. The webs are spaced 21 in. apart and are connected on the center lines of the trusses by vertical riveted diaphragms. The bottom chords of the trusses are seated on the 34-in. cover plates of the girders directly over the diaphragms, and the expansion ends are engaged by guide strips riveted to the girders. The transverse girders weigh about 3,500 lb. each and the weight of the towers exclusive of the girder varies from 40,000 lb. for a tower 48 ft. high and 30 ft. wide to a maximum of 246,000 lb. for the center tower 40 ft. wide and 204 ft. high.



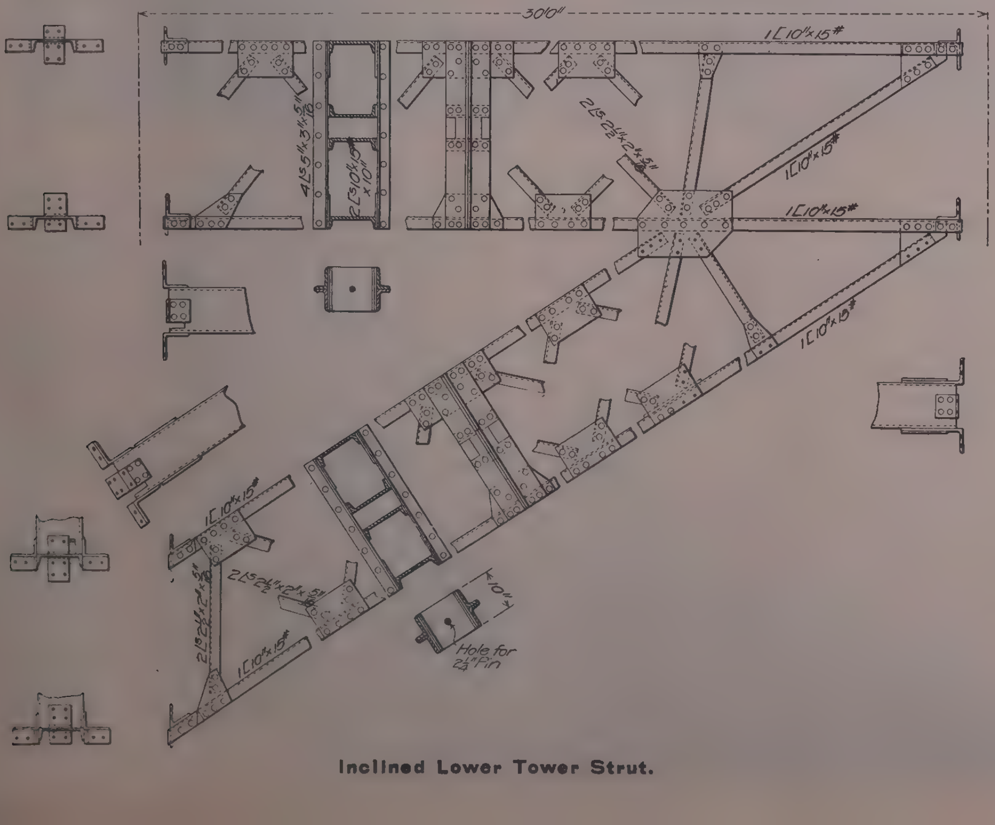
Riveted Truss Span.



Base of Tower Column.

In the outer towers the columns are of a different type made of two 18-in. 75-lb. I-beams spaced 14 in. apart on centers and connected by flange tie plates and lattice bars and by diaphragms joining their webs at the ends. The connection details are substantially as described for the other type of columns. The tower spans 29 ft. 8 in. long over all are structurally independent of the towers and are connected to them only through the lower flanges of their bottom chords. The span has two riveted trusses 12 ft. deep and 10 ft. apart on centers, divided into two 14-ft. 10-in. panels and having end clearances of 4 in. with the intermediate spans. The top and bottom chords are made of pairs of 12-in. and 15-in. channels, respectively, the former having a top cover plate which is not required for the latter. Both were shipped in single full-length pieces. Holes 5 17/32 in. in diameter, are bored in the ends of the top chord for the pins to which the erection links are attached. The diagonals have I-shaped cross-sections, made of two pairs of angles back to back latticed, and the verticals are made of single pairs of angles latticed. Web members are field-riveted to connection plates shop-riveted to the chord webs. Horizontal connection plates are field-riveted to the lower flanges of the top chord and the upper flanges of the bottom chord for the transverse and lateral bracing. The trusses are cambered 5/16 in. Each span weighs about 26,000 lb.

The 40-ft. and the 55-ft. spans correspond essentially to the 30-ft. tower spans and differ from them chiefly in dimensions, in size of materials, in the slotted holes provided for bearings in the base plates at one end of each truss and in the connection plates for web members which are field riveted to the chords. The chords are shipped in two lengths, each with field-riveted web and flange splices. The 75-ft. spans are like the 55-ft.



Inclined Lower Tower Strut.

span except in the dimensions and materials of the trusses, which have their top and bottom chords each shipped in three pieces and have the web-connection plates shop-riveted to the bottom chords and field-riveted to the top chords. Each truss is cambered ¾ in. and the span weighs about 50,000 lb.

The Las Vacas viaduct is now under construction for the Guatemala Railway Co., Mr. Minor C. Keith, president, in accordance with the plan recommended by Mr. Virgil G. Bogue, consulting engineer. Mr. A. W. Buel is Mr. Bogue's associate on bridges; Mr. S. F. Shaw is chief engineer, and Mr. J. H. Pope bridge engineer of the railway company. The Baltimore Bridge Co. is the contractor for the steel work, and Mr. W. T. Penny is the contractor for erection and track laying.

Street Railway Track Construction in Rochester and Buffalo.

With the increasing weight of street-railway and interurban cars, the problem of satisfactory track construction in paved streets is growing in importance, and attention is therefore called to papers on the subject recently read before the Street Railway Association of the State of New York, at a meeting in Buffalo, N. Y., by Mr. I. E. Matthews, engineer of maintenance of way, Rochester Railway Co., and Mr. F. D. Jackson, engineer of way, International Railway Co., Buffalo.

The selection of the proper track construction for any given street will depend, according to Mr. Matthews, on the class of traffic which will use it. For a street of heavy traffic, one would expect to use stone blocks with a correspondingly heavy track construction. Where traffic is light, brick or asphalt might be selected as paving and a lighter track construction would be used. In either case a concrete foundation at least 6 in. in thickness under the ties is recommended. Under the concrete foundations and about 1 ft. outside of the outside rails there should be laid a 3-in. farm tile drain in coarse gravel with joints covered with gunny cloth, and connecting with surface sewers or manholes. It should be at least 2½ ft. below the grade of the finished pavement and covered with coarse gravel for a width of 6 in. and up to the bottom of the concrete foundation under the pavement. The sub-grade should be crowned so as to render the drain more effective.

The type of construction best adapted to streets of heavy traffic in the opinion of Mr. Matthews, is the 9-in., full-grooved rail, well tied with Georgia pine ties, spaced 24 in. to 30 in., center to center, and laid on a 6-in. concrete base. The concrete should be Portland cement one part, sand three parts, and broken stone which will pass through a 2-in. ring, six parts. This concrete should be laid at the same time as that for the foundation of the adjoining pavement and should be carefully tamped under the ties and rails. A grout of one part Portland cement to two parts sand should be poured around and under the rail, to give a firm and uniform bearing. The space between the flange and head of the rail should be filled with a one-to-three mortar. Medina sandstone blocks, resting on 6 in. of concrete and with joints thoroughly grouted, complete this construction which is that used by the Rochester Railway Co. on streets of heavy traffic. The cost has averaged $5.80 per lineal foot of track. Using the same track construction, but with brick paving, the cost has been $5 per lineal foot.

In recently rebuilding the University Ave. line of the Rochester Railway Co., a concrete beam construction under the rails was adopted. The beam is 12 in. in depth below the base of the rail and is 18 in. wide under the outside rails, and 14 in. wide under the center rails. Wooden ties are spaced 5 ft. center to center, the beam being carried to a depth of 8 in. under the ties. Ninety-four-pound, 9-in. girder rails, held to gauge by brace tie plates at each tie, rest solidly on the continuous concrete beams. The pavement between the tracks and 2 ft. outside is of Medina block, the paving in the street beyond being asphalt. This construction costs $5.06 per lineal foot of track. University Ave. would not be classified as a heavy traffic street, but by using the concrete beam a stone block pavement was obtained at about the same cost as the brick pavement with solid concrete foundations. To render the continuous concrete beam construction satisfactory, the concrete foundations of the track and pavement should be thoroughly bonded together.

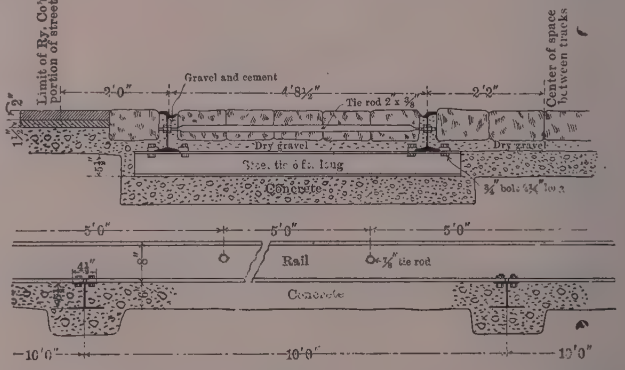
Mr. Matthews believes that in streets of heavy vehicle traffic the cost of maintenance of the paving might become excessive with the T-rail, but that on all other streets the T-rail would be preferable to the grooved rail, both because it is cheaper in first cost and because it gives the bearing of the wheel squarely over the center of the base. The base being wide, there is no tendency to overturn, and the flangeway formed by the special paving blocks now on the market give a groove which is as self-cleaning as that of the grooved rail. With the T-rail the amount of wear that can take place before the track is entirely worn out is independent of the car wheel flanges.

Concrete stringers, with and without ties, and solid concrete in the track, were the types of construction discussed by Mr. Jackson. Many engineers question the advisability of too rigid a track construction, claiming that inelasticity of the roadbed causes undue wear on the rails. According to Mr. Jackson measurements made of rails on a line operating a one-half minute service do not bear out this statement. The head of the rail was found to have worn ⅛ in. in about four and one-half years, which would give a life for the rail under this very frequent service of more than sixteen years, before the ¾-in. flanges would commence to touch the bottom of the groove.

On the Buffalo lines the concrete stringer idea has been modified by laying a solid bed of concrete the entire width of the roadbed 6 in. deep and 6 in. under the ties, instead of having a concrete beam under each rail. This style of construction is used with tracks laid in block paving. In streets paved with asphalt a concrete beam 12 in. wide by 8 in. deep is placed under each rail. This beam is not bonded to the concrete which forms the paving foundation, so that in fact there is no concrete except under each rail. The solid concrete construction with stone paving has been adopted as the best style of work. Of the 194 miles of city tracks, 62 miles are of the concrete beam construction and 87 miles of the sold concrete construction. The remaining 45 miles is old-style work mostly on lightly traveled lines where sand, gravel or stone ballast is used.

With the solid concrete base Carnegie steel ties and tie-rods on 5-ft. centers are used. In laying several miles of double track of this style of construction during the past year a trench 18 ft. wide was first dug to 15 in. below the surface of the street. The 9-in. rail was laid and bolted with four bolts and clips to Carnegie ties spaced 10 ft. center to center. These ties are of I-beam section, 6 ft. long, 5½ ft. deep, and weigh 19.7 lb. per foot. The top and bottom flanges are 4½ and 8 in. wide, respectively. The track was then surfaced and lined by blocking up under the ends of the ties, and ⅞-in. tie rods were put in and a 6-in. trench dug under each tie.

Concrete, proportioned one part of Lehigh Portland cement, three parts of clean, sharp sand and five parts of 2½-in. stone, was put in by a Foote continuous mixer. One pair of wheels ran on the asphalt outside the tracks and the other pair on 5-ft. planks properly blocked up so that no weight was brought upon the track. The concrete was shoveled into the trench to a depth of 6 in., was well tamped under the rail, and was then thoroughly pounded after being leveled to the top of the ties. Three ties were kept tamped ahead of the mixer to insure thorough work at the ties. Four hundred feet of single track were concreted per day of ten hours. This work includes the space within the rails, 2 ft. on the outside and 2 ft. in the devil strip. By the use of the continuous concrete mixer a uniform mix was secured for the entire job with a saving of about 10 per cent. of cement. The pavers followed behind the concrete gang, using 3 in. of coarse gravel as a cushion for the No. 1 Medina block. Full stone paving was employed between the rails and in the devil strip, and toothing was laid along the outside of the track to receive the asphalt, which was placed up against it. The stone paving was then pounded and slushed with a grout composed of a mixture of one part cement to two parts of sand, which completely filled up the voids between the stones, making a perfect bond. This style of construction costs about $5 a running foot of single track, as against $4.50 where wooden ties and tie-rods at 10-ft. centers are used. Part of this increase in cost is due, according to Mr. Jackson, not only to the extra cost of steel tie over wood and to an extra tie-rod, but also to the higher price of labor and material.



Cross Section of Concrete and Steel Tie Track in Buffalo.

A Machinery Exchange has been in operation in the Oliver Building, Boston, during the last three or four months under the management of Mr. E. U. Heath. A number of companies dealing in wood-working machinery, railway and general contractor's supplies, air compressors, mill furnishings, conveyors, lubricants, power plant and the like, have opened district offices in this building, in a common room on the ground floor, the main object sought in doing so being to group together for convenience a number of non-competitive engineering supply houses. Thus far only a few displays of apparatus have been made, but there is a prospect that at least the smaller machines will be exhibited more generally as time progresses. The project resembles that of the Philadelphia Bourse, only it is as yet on a smaller scale and no power-driven apparatus has been set up. Public telephone and stenographer's services with a special consulting room are provided, and a large additional space is now being prepared for the accommodation of those who were too late to secure a part of the original quarters.

The Owens River Aqueduct for the Los Angeles Water Supply.

The Board of Public Works of Los Angeles retained last year Messrs. John R. Freeman, Frederic P. Stearns and James D. Schuyler as a board of consulting engineers to report on the practicability of securing a water supply from the Owens River and its tributaries by means of an aqueduct over 200 miles long, having a capacity of about 400 cu. ft. per second and a total fall of about 3,500 ft., built through a country ranging from rough to mountainous. A study of the water problem of the city had been made by Messrs. Wm. Mulholland and J. B. Lippencott, now chief engineer and principal assistant engineer, respectively, of the Los Angeles Aqueduct, who agreed that the plan of taking water from the Owens River, suggested by Mr. Frederick Eaton, ex-city engineer of Los Angeles, was the most feasible one. The reasons why such a distant source of supply is considered the only one available were outlined in The Engineering Record of Nov. 3, 1906. The Water Commissioners, acting on these preliminary investigations, quietly secured a reservoir site and 40 miles of riparian property on the river, and their action has been ratified by the citizens.

Lake May, One of the Tributaries of Owens River.

Before any further expense was incurred the three engineers named were asked to review the plans, and from their report the following notes have been taken:

Sources of Supply.—Measurements of the flow of Owens River and its tributaries were made by the United States Geological Survey for two years beginning in August, 1903, and measurements of the flow of the river have been continued during the past year by the City of Los Angeles. Therefore there are now available measurements of the run-off for three years, which fortunately include normal, dry and very wet years. By comparing these measurements with others on the adjoining westerly slope of the Sierras, where records of the rainfall and stream-flow for a period of sixteen years are available, it is possible to deduce by analogy the minimum discharge which may occur in the river and its tributaries during seasons of more acute drouth than the driest in which measurements have been recorded. After a study of all these measurements and of the computations which have been made, the consulting engineers agree with the report submitted by the engineers of the Los Angles Aqueduct, that 410 cu. ft. of water per second can be depended upon with the regulation of the proposed Haiwee reservoir alone in years similar to those in which measurements of the Owens River have been made, and that with the further aid of the proposed Long Valley reservoir 410 cu. ft. per second can be depended upon in years as dry as any that have occurred upon the adjoining watersheds in the past sixteen years.

The Owens River water has been analyzed by Prof. L. J. Stabler, of the University of Southern California, who reported as follows concerning it: "This is good water for domestic purposes. The alkali-forming salts are small, consequently it is good for irrigating purposes. The lime and magnesia salts are present in small quantity; this fact shows the water would not form a bad scale if used in boilers. The water would be fairly soft for laundry purposes." A comparison of the water of the Owens River and its tributaries, and of the water now supplied to the city of Los Angeles, shows that the Owens River water is much softer than the present municipal supply, which contains from two to three times as much dissolved mineral matter as the water of the river.

The examination of the streams in the Owens valley showed that the creeks coming from the Sierras furnish water which is clear, colorless and attractive, and the water in the river, being the combined flow of these creeks, is of similar character, but has a slight turbidity and stain owing apparently to drainage from marshes and the return water from canals and irrigated lands. This feature would make the water somewhat objectionable if the latter were to flow directly from the river into the city pipes. It has little or no significance in the present instance, where the water, after being taken from the river, is to be held for a long time in a large storage reservoir where the mineral particles which produce the turbidity will have time to settle. The long period of storage in the reservoir will also be an important safeguard against the transmission of disease germs should any enter the water of the river, because it has been found both by experiment and experience that disease germs are all, or nearly all, destroyed where the water is held sufficiently long in reservoirs.

Although the storage of water in a reservoir has a favorable effect in the directions indicated, it sometimes promotes the growth of water plants or algae which make the water less palatable and attractive. These growths are liable to occur with any water, and have very little, if any, sanitary significance. It is not feasible to prevent them, the engineers report, but it is feasible to remove their effects by aeration and filtration. There is an abundance of surplus fall available for aeration below the proposed Haiwee reservoir, where the water will either flow for several miles down the natural bed of the stream, or be discharged with great force against impulse wheels, in either case receiving most thorough aeration. In the opinion of the consulting board, water which has been stored thus and subsequently aerated, will be of better quality at its exit from the aqueduct than when taken from the Owens River.

Outline of Works.—The plan contemplates the building of an aqueduct of sufficient capacity to deliver a continuous flow of 400 cu. ft. per second. Starting at the point of intake on Owens River, about 12 miles above the town of Independence, the main canal to the Haiwee Reservoir, a distance of 60 miles, will have a capacity of 700 second-feet at the outset, increasing as the side streams are crossed until it is 900 second-feet. This large capacity is provided to gather as much flood discharge as practicable, and convey it to the main storage reservoir at Haiwee Meadows, whence it is to be drawn at a uniform rate of 400 second-feet, plus an additional amount, estimated at 10 cu. ft. per second, for evaporation losses en route.

For the first 20 miles through the Owens valley the canal will be sufficiently below the normal water plane in clayey soil of close texture to require no lining, but for the remaining 40 to the reservoir it will be lined on the bottom and sides with masonry laid in Portland cement and plastered in a manner intended to prevent a loss of water, thus forming a canal of sufficient stability to withstand all ordinary vicissitudes.

The hydraulic grade at the head-works is 3,820 ft. above sea-level, and the proposed high-water line of the reservoir is El. 3,760 ft., giving a total fall of 60 ft. to the canal, or an average of 1 ft. per mile, from the intake to the Haiwee reservoir.

From the outlet of the Haiwee reservoir (low-water elevation 3,695) to Little Lake, a distance of 15.5 miles, there is a total fall of 310 ft. Under the revised plans 270 ft. of this drop may be made available for power whenever the demands will justify its development. To reduce the immediate expenditures it appears best to construct this 15 miles as an open conduit of small section lined with masonry, following smooth ground along a steep natural gradient, thus utilizing the fall to increase the velocity of the water and lessen the size of the conduit. Whenever a demand comes for the development of power in this somewhat remote locality a new line of conduit can be built along the higher elevation following the contour of the hills at a less steep gradient, thereby saving fall for the development of power. After more complete surveys of the high line it may be found that its additional cost need not defer its construction, especially if there is a prospect of the demand in the not distant future for the 7,000 h.p. which can be developed.

From Little Lake to Indian Wells, a distance by the conduit line of 24.5 miles, there are more than ordinary difficulties, as the line must be supported on the mountain sides 200 to 500 ft. above the valley along which the highway follows at the base of the Sierra. Here a succession of tunnels, siphon pipes and bench conduits, excavated much of the way in solid rock, and covered from the outset with reinforced concrete, are required. The siphons are eight in number, having a total length of 3 miles and a maximum head of 150 to 450 ft., while the tunnels have a total length of 5 miles.

From Indian Wells the line enters upon a section of smooth, open valley land extending 20 miles, where the excavation will be comparatively easy, with only 3,750 ft. of steel flumes and siphon pipes for crossing dry washes that come out from the mountains.

Beginning at the summit of the ridge dividing Indian Wells valley from Red Rock Canyon, and extending a distance of 21.5 miles, the second difficult section of the work is encoutered, requiring about 8 miles of tunnels, 3.5 miles of steel flumes and siphons, and 10 miles of concrete lined and covered conduit. A considerable portion of this distance, however, is through indurated clay, sand and shale, which is not difficult of excavation, although extremely broken in surface topography. In this division the line must be carried across a canyon with a siphon pipe having a maximum head of 850 ft.

After passing this broken ground, the conduit emerges upon smooth plains, where a canal may be built at a minimum cost, crossing the Southern Pacific R. R. some 2 miles north of Mojave, and extending entirely around the head of the valley, west of Neenach, to a point nearly south of Fairmont. In all this distance of 64.5 miles there are but two exceptions to the unbroken smoothness of the gently sloping plain, covering a total distance of about 6 miles.

The aggregate length of the aqueduct may be summarized as follows: Unlined canal, 22.20 miles; conduit lined with rubble masonry or concrete, 164.53 miles; tunnels in rock, 18.24 miles; tunnels in earth, 10.11 miles; siphons of steel pipe crossing canyons, 8.99 miles; steel flumes crossing shallow and narrow depressions, 1.80 miles; making a total of 225.87 miles. The conduit has been estimated with a cover of reinforced concrete for a distance of 19.02 miles, or 11.6 per cent. of the entire lined section, the remainder to be left open for the first five years of operation.

The use of the following values of "*n*" in the Kutter formula was recommended in the report: For open masonry conduits of cement or smoothly plastered masonry, 0.018; for concrete-lined tunnels, or covered masonry conduits, 0.014; for steel pipe with rivet heads and seams projecting on the interior, 0.016; for earth canals with bottom as left by dredging, 0.0275.

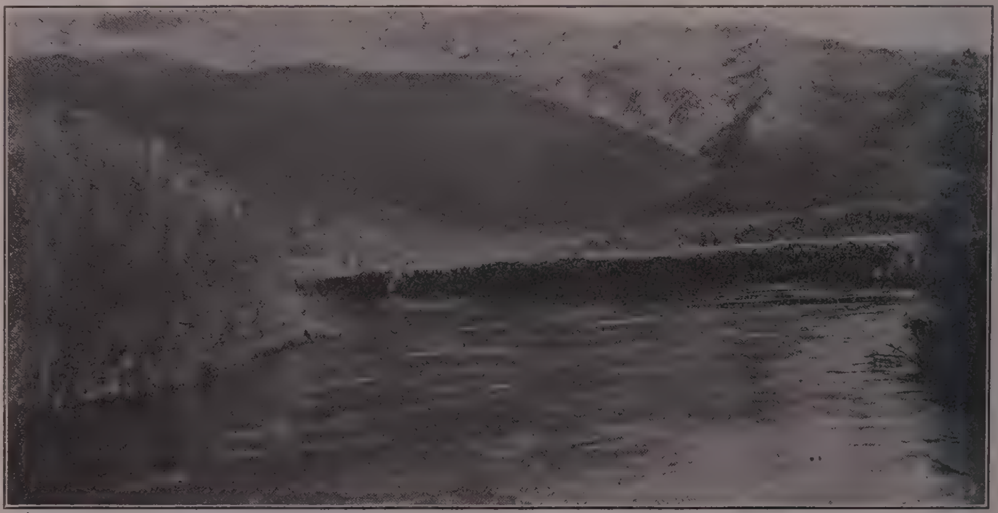
In proportioning the aqueduct between Haiwee reservoir and the San Fernando Valley to convey a mean flow of 410 ft. per second, including evaporation loss, the consulting engineers based their estimates upon a capacity 5 per cent. greater, thus providing for a delivery of 430 cu. ft. per second, in order that the reservoir might be replenished within twenty days after having been depleted by the interruption of flow in the aqueduct.

Reservoir Sites.—The most important reservoir site on the line of the aqueduct is the first below the intake, as it affords a means of direct equalization of the flow of the main canal and the streams gathered by the canal. The reservoir is situated on a summit in the valley, from which the natural drainage is in both directions, north and south. It has a length of 7.4 miles, measured along the thread of the valley, the south dam being the larger of the two, 70 ft. in maximum height with a top length of 900 ft. Materials in the vicinity are favorable for the erection of safe, substantial dams of earth at both sites.

The capacity of this reservoir at the elevation of 3,760 ft., as surveyed by Mr. Mulholland, is computed at 63,780 acre-feet. By building the dams 10 ft. higher this capacity may be increased to 82,350 acre-feet, a most valuable increase in storage, although requiring a diminution of the fall in the main feeder canal by 10 ft. in 57 miles.

The Long Valley reservoir, with a dam 140 ft. high, has a capacity of 260,000 acre-feet, or 85,000,000,000 gal. in round numbers, which is several times the largest existing reservoir in the State. A study of the records of water measurements by the United States Geological Survey for three years on Owens River, and a comparison with longer records of stream-flow on Kings River on the western slope of the Sierras, indicates that when this reservoir is created, the equalization of seasons of extremely large run-off with that of dry years will effect a saving of water which is now lost to all useful purposes, amounting to about 80 cu. ft. per second, in addition to the water controlled by the aqueduct and owned or appropriated by the city. This addition is necessary to ultimately securing in years of excessive drouth, the full amount of 400 second-feet, for which the aqueduct has been designed.

At the Long Valley dam-site the river has cut a deep channel through tufa rock, which is much lighter than granite but sufficiently strong to be relied upon as a satisfactory foundation for the construction of any type of dam which may be decided upon. The reservoir site is admirably adapted to the regulation of the river-flow, and to the substanitial increase of the water supply of the aqueduct by equalizing storage, and the board recommended that it be considered as an essential factor in the general plan, to be developed as early in the future as may be possible. As this regulation of the river is only required when the demand has reached the maximum aqueduct capacity and to provide against a series of dry years, it has not been included in the estimates or considered as an essential feature of the system for immediate construction.



Owens River at the Site of the Proposed Intake.

Estimates of Cost.—The estimates of cost of the Los Angeles aqueduct have been made up of the following general sub-divisions, whose leading characteristics have already been described.

First Division. This extends from the headworks on Owens River to the Haiwee upper dam and consists of 115,400 ft. of unlined canal, of 700 to 800 second-feet capacity, and 198,500 ft. of masonry-lined canal, of 800 to 900 second-feet capacity. Its total length is 313,900 ft. (59.40 miles), with an estimated cost of $3,712,100, and an average cost per foot of $11.85.

Second Division. This is a regulating reservoir with a capacity of 63,780 acre-feet. The estimated cost of the dams and accessories, and the diversion of the highway around the reservoir, not including land damages, is $316,800, and the average cost per acre-foot of capacity is $4.97.

Third Division. This extends from the regulating reservoir to Little Lake, a total distance of 81,700 ft. (15.5 miles), with a gradient exceeding 1 per cent. for the first 3 miles, and 2 ft. per thousand for the remainder. This is the first and easiest division of the aqueduct proper. It is designed to carry 410 second-feet with an ample factor for safety, and is lined throughout and covered where the drainage of the country must be passed over it. Its estimated cost is $481,800, and its average cost per lineal foot is $5.90.

Fourth Division. The line from Little Lake to the south end of the siphon crossing of Indian Wells canyon, a total distance of 127,935 ft. (24.24 miles involves the construction of 27,220 ft. of tunnels, 85,000 ft. of conduit lined with masonry and covered throughout, and 15,715 ft. of siphon pipes. The total estimated cost is $3,088,400, and the average cost per foot is $24.14.

Fifth Division. This is the Valley section from Indian Wells to Red Rock Summit, a total distance of 106,000 ft. (20 miles), consisting of 102,250 ft. of conduit, with 3,000 ft. of cut some 20 ft. deeper than the normal, 1,050 ft. of steel flumes, and 2,700 ft. of siphon pipes. The total estimate is $914,600, and the average cost per foot is $8.63.

Sixth Division. This is a difficult section, 98,600 ft. long (18.66 miles) from Red Rock Summit to the Antelope Valley, requiring 39,272 ft. of conduit, lined with concrete, 6,000 ft. of flume, 41,700 ft. of tunnels, and 11,628 ft. of siphon pipes. The total estimated cost is $2,760,900, and the average cost per foot is $28.

Seventh Division. This extends to the west end of Antelope valley and the portal of the long tunnel. Its total length is 359,200 ft., or 67.81 miles. This division includes 3,970 ft. of siphon pipe, 1,270 ft. steel flume, 475 ft. of tunnel, and 353,485 ft. to conduit lined with concrete. The total estimated cost is $3,076,000, and the average cost per foot, $8.56.

Eighth Division. This is a tunnel 25,000 ft. (4.74 miles) in length. Its total estimated cost is $1,913,200, making the average cost per foot $75.33.

Ninth Division. From the diversion dam to the point of delivery in San Fernando Valley is a total distance of 80,150 ft. (15.18 miles), embracing 55,270 ft. of tunnel in earth or sandstone, 9,440 ft. of conduit, 2,240 ft. of flume, and 13,200 ft. of siphons. The total estimated cost of this division is $1,957,500, and its average cost per lineal foot is $24.45.

The total of these subdivisions is a distance of

1,192,525 ft. of constructed line, aside from the Haiwee reservoir length, or 225.87 miles, the estimated cost of which is $18,221,300. To this total must be added the following: For construction railway, telegraph and telephone line, less a reasonable salable value on completion of the aqueduct based on $350,000 as the estimated scrap value of materials, $1,150,000; for cement mill, $300,000; for temporary water supply for construction purposes and its maintenance during the period of construction, $300,000; for fencing uncovered aqueduct and for permanent residences of caretakers, $125,000; for engineering and contingencies, 15 per cent., $3,014,400; for land and water rights, and for all legal and other expenses connected with their acquisition, $1,375,000; making the estimated total cost of the entire work, $24,485,600.

In commenting on these estimates the consulting engineers in their report said: "The foregoing estimate of probable cost is made according to our best judgment, using the results of our personal experience, and all the data we have been able to collect of the cost of large works of similar character, but it should be clearly understood that the modifications of the line and grade of the aqueduct proposed by the Board have in some cases carried the new locations beyond the limits of the definitely mapped topography on either side of the located line. In the most difficult sections, however, our revised location has been instrumentally re-examined in detail, and checked. In less important places where it was manifest that there was no material changes of material within a short distance of the original location, the estimates have been made on the original line, generally parallel with and not far distant from the new line. In forming our judgment of the cost of excavation, we have been guided in part by our own observations, and in part by the notes of the classification of materials made on the ground by the field engineers. We have assumed that the cement will be manufactured at a cement mill to be erected by the city on property already acquired, and that the cost of the cement at the mill will be $1 per barrel, which is substantially the cost as determined by Mr. Edward Duryee, the cement expert in the employ of the city."

Time Required.—Five years is the minimum time in which the projected works can be completed, in the opinion of the consulting engineers. The controlling feature in determining the time is the long tunnel, which will be about 25,000 ft. long, exclusive of the deep approaches at its two ends, and must be driven from only four headings, two of which will start from a shaft about 350 ft. deep. It will take the larger part of a year before work can be actively begun on the tunnel proper, and about four years more for the excavation of the tunnel and lining it throughout with concrete masonry. Five years also appears as little time as may be prudently reckoned for the completion of the long series of shorter tunnels in the rugged country traversed by section of the conduit.

Due consideration of economy dictates that work should not be begun on these northerly tunnels until the railroad pertaining to the aqueduct has been extended far enough north to give convenient access to them, and until suitable power plants have been provided, operated either by steam or water, as may be found most convenient and economical. While these tunnels are all short in comparison with that first mentioned and any one can be constructed much more quickly than it, there will be economy in avoiding unnecessary duplication of plant for carrying them all on simultaneously, and five years from the present time appears little enough to allow for completing them all.

The present condition of the labor market and the fact that less work can be accomplished in an eight-hour day than in a ten-hour day must also be taken into consideration in considering those portions of the work outside of the tunneling. On certain of the transcontinental railroad extensions now being made to the Pacific Coast, it is reported that much less rapid progress than desired is being accomplished because of the scarcity of labor.

Water Power.—There are three localities along the line of the aqueduct where a surplus fall exists that will permit the development of power from the water flowing toward the city. The most important of these localities is about 45 miles northerly from Los Angeles, where a total drop of nearly 1,500 ft. is available. From present indications it appears most advantageous to divide this fall between two power drops, of which the upper one, the first to be developed, would have about 1,060 ft., and the lower about 415 ft. of net available fall on the water wheels, furnishing 25,000 and 11,000 h.p. respectively. A third site for power development is found a short distance below the end of the aqueduct in the San Fernando valley. The net fall available at this point would be about 215 ft. and furnish about 6,000 h. p. The fourth power site is found nearly 150 miles from Los Angeles, and about 15 miles down stream from the proposed Haiwee reservoir. The net fall available at this point would be about 270 ft., yielding 7,000 h.p. With an average delivery of 400 cu. ft. of water per second, there could be developed at these several points and transmitted to Los Angeles, after making due allowance for the losses in generation and transmission of electrical power, a total of 49,000 h.p., measured in 24-hour electrical horse power at the point of delivery.

It is also possible, by means of small and inexpensive dams, to produce small equalizing reservoirs immediately downstream from each of the first two power houses, so that the water can be drawn at a varying rate throughout the 24 hours, and storage can be accumulated over Sunday, while the aqueduct delivers continually at the normal rate of 400 cu. ft. per second.

Considering that an ordinary factory working 9 hours per day, or 54 hours per week out of the 168 hours, and thus having a load factor of 32 per cent., could be supplied with 300 h.p. during working hours from the same volume of water that is required for developing 100 h.p. continually 24 hours per day and seven days per week, the great value of equalizing reservoirs and conduits suitable for a higher rate of delivery during the hours of greatest demand becomes apparent. The load factor for future conditions and after the building of more factories may be different from that for present conditions of railway and lighting use.

The consulting board for this reason planned the long tunnel and estimated its cost with diameter and gradient such as to permit drawing the water from the reservoir at 2½ times the average rate, or at the rate of 1,000 cu. ft. per second, during those hours on which the demand for power is greatest. Under this arrangement it will be feasible to install electrical machinery, and supply power during the hours of maximum use up to about 60,000 h.p. at the upper power house, and about 20,000 h.p. at the lower power house. So far as is shown by the surveys thus far made, it will not be expedient to provide for a large peak load increase at the other stations.

The power that may be developed under the 40 per cent. load factor at the two important sites is therefore 80,000 h.p., and adding to this the 13,000 h.p. that may be developed at the other points gives a total of 93,000 h.p. measured at the point of delivery in hours of greatest demand, which may be developed from the Owens River water along the course of the proposed aqueduct. The conditions for the economical development and maintenance of the power are very favorable, and its safety against interruption or diminution by drought, and the permanent character of the aqueduct tend to make the power development feature particularly attractive and valuable.

Engineering Organization.—The work of building a water-tight and durable aqueduct, erecting safe and stable dams, and of constructing the great steel siphon pipes which will be required, is of a far more exacting character than a railroad construction, according to the Board. The Los Angeles aqueduct is a work of such magnitude and extends over so many miles of territory somewhat remote from the base of supplies, that it will be a physical impossibility for the chief engineer and the principal assistant engineer to be upon all parts of the line frequently enough to give the quick decision necessary for overcoming obstacles. It will, therefore, be essential, in the opinion of Messrs. Freeman, Stearns and Schuyler, to have in the field engineers of proved executive skill and resourcefulness, who are expert in the line of work which they are to supervise. The consulting engineers recommend substantially the plan of organization which has been successfully adopted on the Metropolitan Water Works of Massachusetts and on the Catskill aqueduct of the Board of Water Supply of New York. Under the chief engineer and the principal assistant engineer the work will be divided into several main departments, each placed in charge of a department engineer having his principal office near the work he is to supervise. There should be an efficient staff at headquarters to prepare designs for the work of construction and to make the necessary studies and investigations. If the work is done in large part by day labor, a somewhat different organization would be required, including men of special skill in several branches of the work.

The conclusions of Messrs. Freeman, Stearns and Schuyler are summarized in the report as follows:

"1. We find the project in every respect feasible, and that it involves no great difficulties of engineering or construction other than those arising from mere length and distance.

"2. That a supply of about 400 cu. ft. of water per second of good quality for domestic use can be brought to the city of Los Angeles or its vicinity from the Owens River and its tributaries.

"3. That the cost of all water rights, land and structures required for the collection, storage and delivery of this water to the San Fernando Valley, but not including the cost of the future Long Valley reservoir or those in the San Fernando Valley, or structures required solely for the development of power, will be about $24,500,000.

"4. That from the water conveyed by this aqueduct, power can be developed and transmitted electrically to the city of Los Angeles and vicinity sufficient to supply 49,000 h.p. every day in the year, or a correspondingly large amount if portions of it are used only during ordinary working hours.

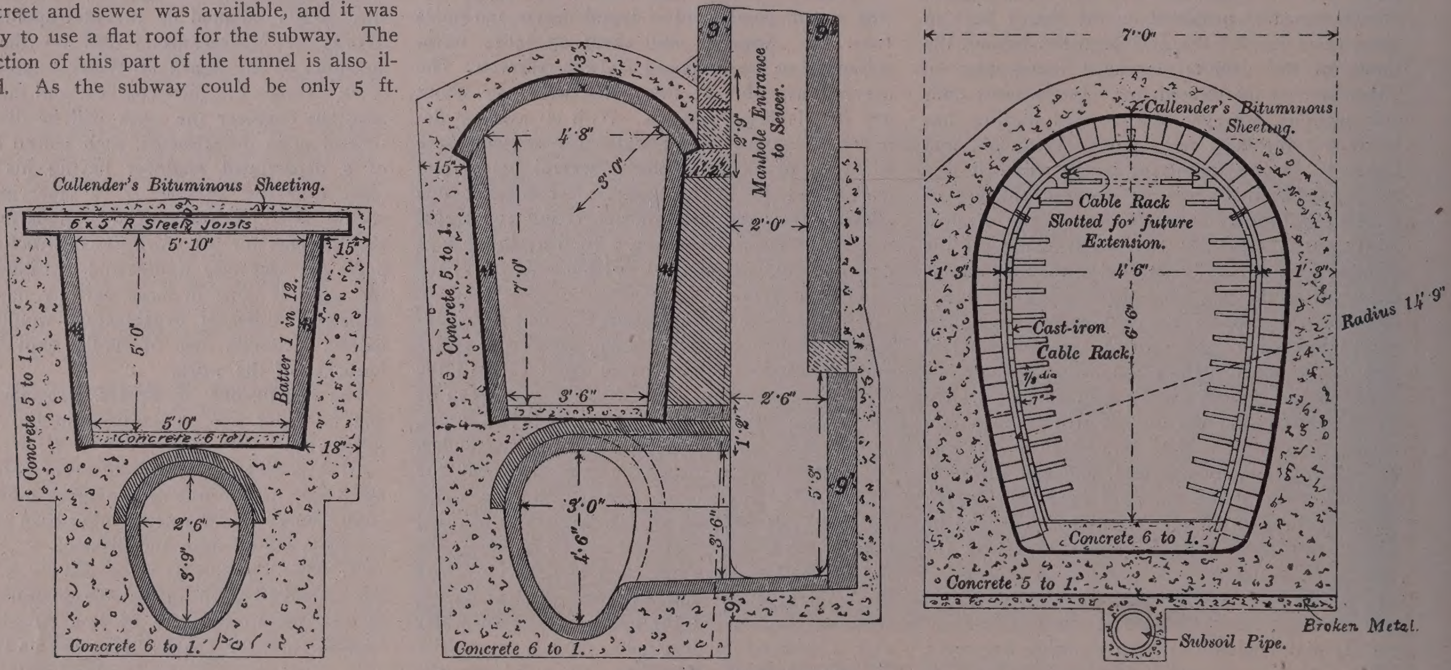
"In brief: We find the project admirable in conception and outline, and full of promise for the continued prosperity of the city of Los Angeles."

Tar Macadam Roadways are being tried in Zurich, Switzerland, under the direction of Street Superintendent Aeberli. According to an account of the work in a consular report, clean gravel from 1.2 to 2 in. in size is heated and mixed in a drum with liquid tar until the pebbles are thoroughly coated. This gravel is then heaped up and covered, and allowed to stand for eight to ten weeks. Stress is laid on this period of rest as materially improving the quality of the product before it is spread and rolled.

The Aberdeen Electric Cable Subway.

An electric subway nearly a mile long in Aberdeen, Scotland, has been built to carry feeder and pilot cables from the Dee Village central station constructed in 1900. The adoption of a subway for these cables was brought about in part by the fact that when various schemes were being considered a new high level sewer was about to be constructed in a street down which forty or fifty cables would have to be carried, and it was decided that the plans could be modified and a subway built over the sewer, thus avoiding the necessity of digging two trenches.

Section 1 runs for 800 yd. from the central station to a distributing chamber. The type of construction in this section varied according to the depth which could be secured between the street level and the top of the sewer. In general the cross-section is that shown in an accompanying illustration, with flaring side walls and an arched cover. The walls are of concrete lined with 4½ in. of red brick. Between the brick lining and concrete is a layer of Callender's bituminous damp-proof sheeting. For a distance of 90 yd. in section 1, only a limited space between street and sewer was available, and it was necessary to use a flat roof for the subway. The cross-section of this part of the tunnel is also illustrated. As the subway could be only 5 ft. high, its width was increased to 5 ft. at the floor level so that three lines of cables could be carried in each insulator pin.



Sections of the Aberdeen Cable Subway.

The flat roof is made with 6-in. 25-lb. I-beams, spaced 3 ft. 6 in. center to center and filled in with concrete reinforced with expanded metal. Bituminous sheeting was carried over the top of the beams and additional concrete was added to give a slope for drainage, as shown in the illustration. As this part of the work was being built, difficulties were encountered owing to a stone sewer in the center of the street. This sewer deviated in line considerably and the subway trench, which was 8 ft. 3 in. wide, often encroached upon it and necessitated underpinning the old sewer arch, in short lengths, with 9-in. brickwork, as it was impossible during construction to divert the sewage into the new sewer.

The greatest depth of the trench in Section 1 was 30 ft. Considerable fine running sand was encountered which required very careful timbering. The concrete side walls were first built up to the springing line of the arch. When they had set sufficiently a lay of damp-proof sheeting was put on. The brick arch was then built and covered with concrete. The inside brick walls were built last, the cable supports being built into the wall every 6 ft. as the work progressed. The brickwork was tied to concrete with iron cramps.

Section 2 extends almost at right angles to Section 1, from the end of the first section to a distributing chamber at a distance of 700 yd. The cross-section used in this portion differs from the other two. It has a horse-shoe shape of the dimension shown in an accompanying illustration. The materials used are the same as in the greater part of Section 1.

The method of construction differs in several respects from that used in the first section. When the ground had been prepared for the subsoil pipes the 10-in. concrete foundation was put down first. The concrete walls were then built up to the springing line of the arch. A length of 36 ft. was, under favorable circumstances, concreted at one time. When the walls were brought up to the height required, V-shaped strips of wood were put along the top to form a key for receiving the concrete on the arch. A fillet of cement was run along the bottom of the walls to round off the corner so as to prevent the damp-proof sheeting from cracking when the weight of the brickwork lining was put on to it. When the foundation and walls were ready the damp-proof sheeting was laid on. The sheets used were 6 ft. wide and cut in lengths of 16 ft. The ends were rolled back on the top of the walls and carefully protected until the arch was turned. The jointing of the sheets was done by means of a special flat hot iron; great care had to be taken, however, not to burn the canvas by overheating the iron. The joints had a lap of 2 in. and were sealed with pure melted bitumen. When a series of lengths of the sheeting had been jointed, the brick lining was built up to the level of the concrete walls and the cast iron cable racks fixed every 6 ft.

Before the centers for the arch were placed in position the 6 to 1 concrete for the floor was put in to protect the sheeting from damage, the 1-in. finishing coat of 1½ to 1 cement mortar being left until the centers had been struck and the soffit of the arch thoroughly scraped and pointed. The brick arch was then laid over specially prepared centers with planed lagging. A layer of the damp-proof sheeting was laid over the arch, and made to overlap the ends of the lower piece. The wooden V pieces were taken out and the concrete put on the top of the arch to the shape shown and brought to a fairly smooth surface by means of shovels.

At some points in the course of the subway an abrupt change in floor elevation was necessary and this was accomplished by a series of concrete steps. Manhole entrances with watertight covers are provided at various places through which cables may be drawn into the subway. Eight-candle-power electric lamps spaced 21 ft. apart, and arranged in sections of twenty-five lamps each, are used to light the passage.

Ventilation is secured by means of two exhaust fans capable together of exhausting about 20,000 cu. ft. of free air per minute. One is placed at the junction of Sections 1 and 2 and the other at the extreme end of Section 2. They are worked simultaneously at intervals for several hours every day, warm air being drawn direct from the engine room at Dee Village. These fans, which are controlled from the generating station, keep the air in the subway in a very pure and cool condition, and rapidly remove all traces of moisture.

The engineer for the works was Mr. William Dyack. Mr. G. R. G. Conway was responsible for the detail drawings and superintendence of the construction, and on Section 2 was assisted by Mr. D. Benzie from whose paper published by the Aberdeen Association of Engineers these notes have been taken. Mr. Benzie is now city engineer of St. Catharines, Ont. The contract amounts for the two sections, inclusive of all diversions of main sewers, etc., was £18,661.

A Uniform Water Rate of 7 cents per 1,000 gal. to all consumers is to be established by the water department of Chicago. The present rates at which water is sold in that city range from 4 to 10 cents per 1,000 gal., depending on the quantity used. These rates are based on meter measurements on independent premises, and are scaled as follows: For quantities up to and not exceeding 165,000 gal. per month, 10 cents per 1,000 gal.; for quantities in excess of 165,000 gal. a month and up to and including 5,000,000 gal. a month, 8 cents per 1,000 gal.; for all quantities in excess of 5,000,000 gal. per month, 4 cents per 1,000 gal. In December, 1904, 4,446 consumers paid 10 cents per 1,000 gal. and 1,261 consumers, 8 cents per 1,000 gal. According to Mr. H. O. Nourse, superintendent of the water department, the new rate will adversely affect not more than 21 consumers. At the same time it will equalize rates and give to every consumer who has a meter a chance to get water at what is considered actual cost. The connections with the distribution mains are only partially metered at the present.

Book Notes.

A paper recently published by the U. S. Geological Survey on the "Purification of Boston Sewage" is an explanation of the work done up to the present time by Messrs. C. E. A. Winslow and Earle B. Phelps at the sewage experiment station of the Massachusetts Institute of Technology. It begins with a careful and elaborate historical review of the whole sewage-disposal problem from its origin in the wide adoption of the water carriage system up to the present time, when that system has become practically universal. Following the historical review is a full description of the experiments thus far made on the sewage of a great American seaboard city, together with comparisons with similar work done elsewhere, with practical conclusions which have been drawn from the experiments and specific statements concerning the comparative merits of various systems of purification tested. These are by no means applicable merely to large cities or to seaboard cities, but contain lessons of practical value for all sorts of communities. This report is published as Water Supply and Irrigation Paper No. 185. It may be obtained, free of charge, on application to the Director of the United States Geological Survey, Washington, D. C.

Interior of Aberdeen Cable Subway.

The lack of a comprehensive account of the Suez Canal has been deplored by all engineers who have had occasion to investigate that great engineering work, and accordingly it is a pleasure to announce the appearance of an elaborate and authoritative treatise regarding it. It is by Voisin Bey, director-general of the construction of the canal, and until lately inspecteur-général of the French bureau of bridges and highways, and is entitled "Le Canal de Suez." In the seven large volumes of text and atlas of plates the author gives an account of the work and the negotiation leading to it from its inception in 1854 down to 1902. The first two volumes are almost exclusively historical and financial. In the remaining volumes the author describes the construction, beginning with the early proposed location surveys, and then taking up in detail the design of different portions of the canal and the operations of the contractors. The author refrains from all criticisms and gives a straightforward narrative. (Paris, H. Dunod & E. Pinat; 90 francs).

A book that should be read by all engineers interested in road construction is the second edition of "Economics of Road Construction," by Mr. H. P. Gillette. Within a compass of 49 pages he takes over his knee and spanks more "authorities" than the most iconoclastic art critic will attack in a big book on painting or music, and we all know that the art critic is usually the most ready writer of adverse opinions in the little circle of those devoted to the gentle art of making enemies. The reason for his poor opinion is readily understood, however, when it is recalled that for many years he has made a specialty of construction economics. As an engineer he has kept in mind the object of the work and as an ex-contractor he has the viewpoint of the fellow who wishes to accomplish that object at the minimum expense. In his opinion a great deal of the work now done is needlessly expensive. He does not believe in narrow, deep ditches; he is not in sympathy with those who believe expensive culverts and fences are necessary; and he considers the specifications for broken stone are often not only too severe but are essentially impracticable of fulfilment. These are just a few of the things which he discusses with a vigor that makes the book decidedly different in style from the usual textbook. In some respects, such as the theory of binders, The Engineering Record prefers the views of the Office of Roads, in others it inclines to a belief that the "standard" specifications have merits when dealing with incompetent contractors that Mr. Gillette hardly appreciates, but as a whole the book is decidedly valuable as an explanation of road building from the viewpoint of the man actually engaged on construction. It takes up earth, gravel, macadam and telford roads, repairs and maintenance, and certain features of specifications which are particularly distasteful to the author. Throughout the discussion, the cost of the different items of the work are discussed in detail in the light of the author's experience, so that nowhere is there any indication of the scissors and paste-pot. (New York, Engineering News Publishing Co.; $1.)

CONCRETE BUILDING BLOCKS are being employed in the construction of the permanent residence of the governor of the Canal Zone, the house being intended for this use after the completion of the canal as well as during its construction. The blocks are made at a plant established at Ancon for the purpose.

Letters to the Editor.

THE NECESSITY OF STRIPPING RESERVOIR SITES.

SIR:—I have read with a great deal of interest your editorial and the synopsis of Messrs. Hazen and Fuller's report to Mr. J. Waldo Smith concerning the advisability of stripping the Ashokan reservoir, published Jan. 5. Without going into the explanatory theories which are injected into the report, I wish to say that my own knowledge leads me to endorse the position of Messrs. Hazen and Fuller in their advice not to strip the area in question. I do not believe that the several Massachusetts impounded supplies referred to, carefully edited as these have been, have as distinct a bearing on this problem as others within the United States, where impounded swamp waters and upland streams from heavily wooded and overgrown tracts are furnishing highly colored, odor-bearing supplies, particularly where filtration has been resorted to more or less successfully in connection with these.

Good examples of supplies of this nature within my own knowledge are those at Charleston, S. C.; Middletown, N. Y.; Lexington, Ky.; Norfolk and Portsmouth, Va., all of these being water carrying algae growths and odors from decomposition. On all of these I believe aeration and filtration are utilized to rid the supply of these detrimental characteristics. In most, if not all, of these supplies the question of expense involved has governed the construction of the impounding reservoir, and in none of these cases has the area been stripped, though in most cases the undergrowth was cut down and burnt. It does not follow, of course, that a city such as New York is bound by any such limitations in the expenditure of money in securing a good water supply; but it is very doubtful, in my opinion, if the benefit to be derived from stripping the area above the Ashokan dam would compensate for the expense involved.

While there is some doubt as to the results following the flooding of the large area to be impounded by the Ashokan dam, for climatic reasons, it is very probable that the consequence will be the development of odors and color in the impounded water, resulting from the combined action of sunlight, organic matter, water and bacterial activity; but these results can be removed at an expense probably much less than the cost of stripping the immense area in question. This statement assumes that filtration will be employed in any case in connection with this supply.

When Prof. Nichols stated in 1883 that nothing could be done to exterminate algae from the ponds in which they grow, his statement did not necessarily cover the condition in 1907; it is well known at this writing that algae can be exterminated by the use of copper sulphate in minute quantities, and this treatment has been found to be rational and comparatively inexpensive in the case of large flooded areas. Messrs. Hazen and Fuller are correct in assuming that growths will occur even though the land has been stripped, and that treatment in any case is inevitable. It would seem to me better practice, after allowing sufficient time for leeching out the first color by impounded water, to waste the water from the reservoir; subsequently on refilling, treatment by copper sulphate, as recommended by the U. S. Agricultural Department, can be resorted to should it prove necessary.

It is logical to assume that mechanical filtration will be installed on account of the color removal to be accomplished. The only factor of purification not wholly to be depended upon, in my judgment, is aeration. The writer has had occasion recently to note the presence of what appears to be Crenothrix in the present supply of New York City, and confidently expects its continuance after the Ashokan supply is added. In this event a further method of purification, consisting probably of treatment in the reservoir itself, will be necessary, even though aeration and filtration be adopted as outlined in Messrs. Hazen and Fuller's report.

Respectfully, Robert E. Milligan.

New York, Jan. 16.

Rail Fastenings.

Sir: I read with interest, in the Dec. 22 issue of your esteemed paper, the account of the tests made by Prof. Webster of the University of Illinois respecting different rail fasteners. I do not think it is possible to draw a conclusion from the few experiments Prof. Webster has undertaken. The wrenching out of a spike or screw-spike by continuous effort with a special machine does not give the right test of the holding power of a rail fastener, the conditions on the track being different from those that can be realized in a laboratory. On the track, there is no direct pull of the screw-spike by continuous effort, no lateral displacement such as can be obtained with the arrangement imagined by Prof. Webster; moreover, there are other causes of destruction, such as hammering, the flexions and vibrations of the line under the influence of passing trains, which are not taken into account.

The only valuable experiment in the matter of track and especially of rail fasteners is the one made in the track itself under the ordinary conditions of the traffic.

Great holding power is no doubt of importance for a rail fastener but it is not all-sufficient. A good rail fastener, in my opinion, must have a certain amount of elasticity, ensure a strong and constant pressure of the rail or its support against the tie; at least it must not be a cause of destruction of the tie.

I do not think anybody will contradict me if I say that the spike, besides not having sufficient holding power to answer present requirements of the traffic, is very harmful to the tie. It is a well-known fact that most ties do not perish through decay, since they are treated, but through the fasteners and especially through the spikes. As soon as the spike is unable to ensure a strong pressure of the rail on the tie and allows some play to exist, then begin the "hammering" and its destructive influence on the tie, which will have soon to be rejected.

The screw-spike is an improvement over the spike and that superiority has been acknowledged by the International Railway Congress held at Washington in May, 1905. However, the screw-spike is not yet an ideal rail fastener, its holding power in soft wood is not very great; it requires frequent retightening and repairing, and does not protect the tie against the destructive action of the rail or its support.

Such are the reasons which have lead me to the invention of my helical linings. I will not enlarge here upon the advantages of these linings which are being used in large quantities by railway companies and are now sufficiently known to American engineers. I will only draw the attention to this fact, that a lining, besides increasing the holding power of a screw-spike, reduces in a great proportion the destructive effect of the rail on the tie by ensuring a strong and constant pressure of the former on the latter. This fact is not the result of a simple test but of six years' experience in the tracks of different railways.

The insertion of those linings is very easily and very quickly done on the track or at the works by means of a special machine, and facilitates a good fixing of the screw-spike. Should any of the readers of this paper feel interested in the subject, I shall be pleased to let them have the paper I have recently published on my "Helical Linings."

Before closing this letter, I should like to reply to the objection raised by Prof. Webster respecting the possibility of repairing the spikes or screw-spikes turning loose with my helical linings. I will only say that this operation is not only possible and advisable, but that my helical linings are actually used in large quantities by European railway companies for that purpose. That is, I think, a sufficient proof of the value of the process. I am, dear sir,

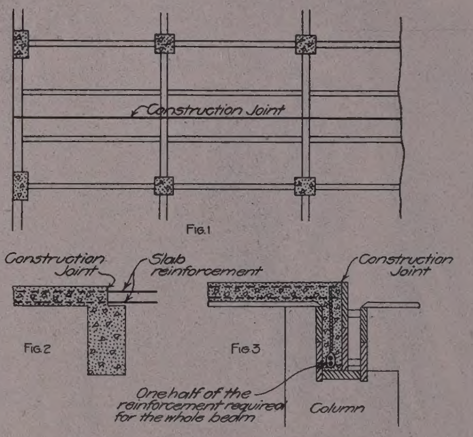
Yours truly, Jean Thiollier.

92 Boul. Haussmann, Paris.

Construction Joints in Reinforced Concrete Work.

Sir: The subject of construction joints in reinforced concrete work is of considerable importance, and merits discussion in your valuable columns. For the purpose of eliciting the opinions of other engineers interested in the matter, the writer will outline his own views.

By reason of the monolithic action desired in a reinforced concrete floor-system, it is desirable to carry on the construction of each floor without intermediate interruptions. This is, however, impracticable in most cases, wherefore it becomes necessary to arrange the joints between each day's work, so that the strength and permanence of the construction will not be materially affected. In relatively narrow buildings, the concreting usually proceeds in sections covering the entire width of the floor, in which case the day's work may be stopped on a straight line running right across the building.



Types of Construction Joints.

Some contractors arrange their construction joint in the middle of a bay, Fig. 1. This of course is based on the assumption, that for uniform loading, the shear is nil along this line. The method has the advantage that the firm connection between the slab and the beams is not disturbed, allowing the latter to act as T beams. The disadvantage is very apparent, as the joint is bound to open under loading, exposing the steel in the slab and girders to the direct action of fire or corrosion. The assumption, that there is no shear at this point, does not always hold good, either. If this method is followed, the joint should be made vertical, and not in an inclined plane, as is sometimes done. With this latter method the concrete will have a tendency to slide rather than to act in compression at the top of the slab and girders.

Another method which is employed by some contractors, is to terminate a section of the floor over a beam or girder, Fig. 2. The slab reinforcement is carried through the joint into the adjoining bay. This method is probably an improvement over the one already mentioned, but even here, the joint is liable to open, causing unsightly cracks in the floor, and even admitting water to the slab reinforcement. It furthermore has the objection that the beam cannot be considered as a symmetrical T section.

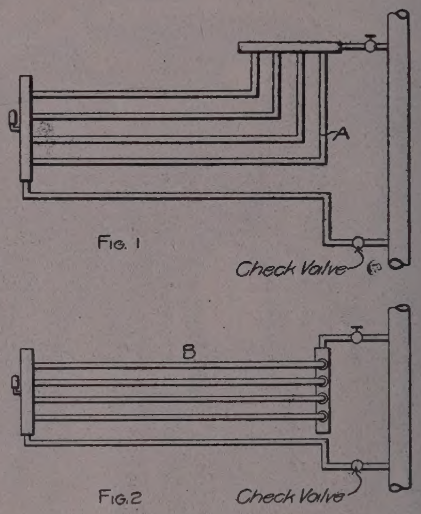
What appears to the writer to be the best solution of this problem is indicated in Fig. 3. The objection to this one is that, in the case of a girder, the beam rods must pass through, which makes the joint difficult of execution. This objection can, however, be overcome by making slots in the separating board for the beam rods to pass through, and patching up the openings around these with cement mortar. In following this method, the construction joint should always be made on a column line, and only half of the column should be concreted to the top of the slab.

Yours very truly, A. Jordahl.

New York City, Jan. 14.

Trouble with Heating Coils.

Sir: The following problem is one I had to deal with recently, and although I was able to remedy the trouble I cannot fully explain the cause of it. Inasmuch as your paper is read by most of the heating experts in the country, I will be glad to have you present it for their discussion.



A Heating Problem.

The steam main is carried to the attic of a four-story building, and a circuit main run around the attic from which drop risers are run down to supply various radiators and coils. The system is on the one-pipe principle; steam is supplied at the top of a coil or radiator and the return is taken from the bottom, a check valve being inserted as shown in Fig. 1. The pressure is about 3 lb. constant.

There are about eighty fixtures, and all but six worked perfectly. In two miter coils, Fig. 1, the bottom pipe marked *A* remained only warm from the return header to the elbow at the miter, when the other pipes were hot. In four angle coils connected as shown in Fig. 2, the top pipes marked *B* were only warm from the return header to the elbow at the angle, while all other pipes in the coils were perfectly hot.

I thought at first that the trouble was due to the position of the automatic air vent, which was the "Perfected Duplex" make in all the work. On tapping this vent on at various points on the return header, the results were in all cases the same. Although I succeeded in making these coils heat as they should, by a method I will explain later, I should very much like to have an explanation of the reason for the trouble and a suggestion as to some method of regularly avoiding it.

Heating Engineer.